SCIENCE

NEW SERIES
VOL. XLIV. No. 1134

FRIDAY, SEPTEMBER 22, 1916

SINGLE COPIES, 15 CTS.
ANNUAL SUBSCRIPTION, $5.00

SCIENCE

FRIDAY, SEPTEMBER 22, 1916

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-On-Hudson, N. Y.

NEW ARCHEOLOGICAL LIGHTS ON THE ORIGINS OF CIVILIZATION IN EUROPE[1]

Et quasi cursores vitaï lampada tradunt

WHEN I was asked on behalf of the council of the British Association to occupy the responsible post of president at the meeting in this great city—the third that has taken place here—I was certainly taken by surprise; the more so as my own subject of research seemed somewhat removed from what may be described as the central interests of your body. The turn of archeology, however, I was told, had come round again on the rota of the sciences represented; nor could I be indifferent to the fact that the last presidential address on this theme had been delivered by my father at the Toronto meeting of 1897.

Still, it was not till after considerable hesitation that I accepted the honor. Engaged as I have been through a series of years in the work of excavation in Crete—a work which involved not only the quarrying but the building up of wholly new materials and has entailed the endeavor to classify the successive phases of a long, continuous story—absorbed and fascinated by my own investigation—I am oppressed with the consciousness of having been less able to keep pace with the progress of fellow explorers in other departments or to do sufficient justice to their results. I will not dwell, indeed, on those disabilities that result to myself from present calls and the grave preoccupations of the hour, that to a greater or less extent must affect us all.

[1] Address of the president of the British Association for the Advancement of Science, Newcastle-on-Tyne, 1916.

But archeology—the research of ancient civilizations—when the very foundations of our own are threatened by the new barbarism! The investigation of the ruins of the past—at the time when hell seems to have been let loose to strew our continent with havoc beyond the dreams of Attila! "The science of the spade"—at a moment when that science confronts us at every hour with another and a sterner significance! The very suggestion of such a subject of discourse might seem replete with cruel irony.

And yet, especially as regards the prehistoric side of archeology, something may be said for a theme which, in the midst of Armageddon, draws our minds from present anxieties to that still, passionless domain of the past which lies behind the limits even of historic controversies. The science of antiquity as there seen in its purest form depends, indeed, on evidence and rests on principles indistinguishable from those of the sister science of geology. Its methods are stratigraphic. As in that case the successive deposits and the characteristic contents—often of the most fragmentary kind—enable the geologist to reconstruct the fauna and flora, the climate and physical conditions, of the past ages of the world, and to follow out their gradual transitions or dislocations, so it is with the archeologist in dealing with unwritten history.

In recent years—not to speak of the revelations of late Quaternary culture on which I shall presently have occasion to dwell—in Egypt, in Babylonia, in ancient Persia, in the central Asian deserts, or, coming nearer home, in the Ægean lands, the patient exploration of early sites, in many cases of huge stratified mounds, the unearthing of buried buildings, the opening of tombs, and the research of minor relics, has reconstituted the successive stages of whole fabrics of former civilization, the very existence of which was formerly unsuspected. Even in later periods, archeology, as a dispassionate witness, has been continually checking, supplementing and illustrating written history. It has called back to our upper air, as with a magician's wand, shapes and conditions that seemed to have been irrevocably lost in the night of time.

Thus evoked, moreover, the past is often seen to hold a mirror to the future—correcting wrong impressions—the result of some temporary revolution in the whirligig of time—by the more permanent standard of abiding conditions, and affording in the solid evidence of past well-being the "substance of things hoped for." Nowhere, indeed, has this been more in evidence than in that vexed region between the Danube and the Adriatic, to-day the home of the Serbian race, to the antiquarian exploration of which many of the earlier years of my own life were devoted.

What visions, indeed, do those investigations not recall! Imperial cities, once the seats of wide administration and of prolific mints, sunk to neglected villages, vestiges of great engineering works, bridges, aqueducts, or here a main line of ancient highway hardly traceable even as a track across the wilderness! Or, again, the signs of medieval revival above the Roman ruins—remains of once populous mining centers scattered along the lone hillside, the shells of stately churches with the effigies, bullet-starred now, of royal founders, once champions of Christendom against the Paynim—nay, the actual relics of great rulers, lawgivers, national heroes, still secreted in half-ruined monastic retreats!

Sunt lacrimæ rerum et mentem mortalia tangunt:

Even the archeologist incurs more human debts, and the evocation of the past carries with it living responsibilities!

It will be found, moreover, that such investigations have at times a very practical bearing on future developments. In connection with the traces of Roman occupation I have recently, indeed, had occasion to point out[2] that the section of the great Roman road that connected the valleys of the Po and Save across the lowest pass of the Julians, and formed part of the main avenue of communication between the western and the eastern provinces of the empire, has only to be restored in railway shape to link together a system of not less value to ourselves and our Allies. For we should thus secure, via the Simplon and northern Italy, a new and shorter overland route to the east, in friendly occupation throughout, which is to-day diverted by unnatural conditions past Vienna and Budapest. At a time when Europe is parcelled out by less cosmopolitan interests the evidence of antiquity here restores the true geographical perspective.

Whole provinces of ancient history would lie beyond our ken—often through the mere loss of the works of classical authors—were it not for the results of archeological research. At other times again it has redressed the balance where certain aspects of the ancient world have been brought into unequal prominence, it may be, by mere accidents of literary style. Even if we take the Greek world, generally so rich in its literary sources, how comparatively little should we know of its brilliant civilization as illustrated by the great civic foundations of Magna Graecia and Sicily if we had to depend on its written sources alone. But the noble monuments of those regions, the results of excavation, the magnificent coinage—a sum of evidence illustrative in turn of public and private life, of art and religion, of politics and of economic conditions—have gone far to supply the lacuna.

Look, too, at the history of the Roman Empire—how defective and misleading in many departments are the literary records! It has been by methodical researches into evidence such as the above—notably in the epigraphic field—that the most trustworthy results have been worked out.

Take the case of Roman Britain. Had the lost books of Ammianus relating to Britain been preserved we might have had, in his rugged style, some partial sketch of the province as it existed in the age of its most complete Romanization. As it is, so far as historians are concerned, we are left in almost complete darkness. Here, again, it is through archeological research that light has penetrated, and thanks to the thoroughness and persistence of our own investigators, town sites such as Silchester in Roman Britain have been more completely uncovered than those of any other province.[3] Nor has any part of Britain supplied more important contributions in this field than the region of the Roman Wall, that great limitary work between the Solway and the mouth of the Tyne that once marked the northernmost European barrier of civilized dominion.

Speaking here, on the site of Hadrian's bridge-head station that formed its eastern key, it would be impossible for me not to pay a passing tribute, however inadequate, to the continuous work of exploration and research carried out by the Society of Antiquaries of Newcastle, now for over a hundred years in existence, worthily seconded by its sister society on the Cumbrian side, and of which the volumes of the respective *Proceedings* and *Transactions*, *Archæologia*, *Æliana*, and last but not least the *Lapidarium Septentrionale*, are

[2] "The Adriatic Slavs and the Overland Route to Constantinople," *Geographical Journal*, 1916, p. 241 seqq.

[3] See Haverfield, "Roman Britain in 1913," p. 86.

abiding records. The basis of methodical study was here the survey of the Wall carried out, together with that of its main military approach, the Watling Street, by MacLauchlan, under the auspices of Algernon, fourth Duke of Northumberland. And who, however lightly touching on such a theme, can overlook the services of the late Dr. Collingwood Bruce, the Grand Old Man, not only of the Wall itself, but of all pertaining to border antiquities, distinguished as an investigator for his scholarship and learning, whose lifelong devotion to his subject and contagious enthusiasm made the Roman Wall, as it had never been before, a household word?

New points of view have arisen, a stricter method and a greater subdivision of labor have become imperative in this as in other departments of research. We must, therefore, rejoice that local explorers have more and more availed themselves of the cooperation, and welcomed the guidance of those equipped with comparative knowledge drawn from other spheres. The British Vallum, it is now realized, must be looked at with perpetual reference to other frontier lines, such as the Germanic or the Rhætian lines; local remains of every kind have to be correlated with similar discoveries throughout the length and breadth of the Roman Empire.

This attitude in the investigation of the remains of Roman Britain—the promotion of which owes so much to the energy and experience of Professor Haverfield—has in recent years conducted excavation to specially valuable results. The work at Corbridge, the ancient Corstopitum, begun in 1906, and continued down to the autumn of 1914, has already uncovered throughout a great part of its area the largest urban center—civil as well as military in character—on the line of the Wall, and the principal store-base of its stations. Here, together with well-built granaries, workshops, and barracks, and such records of civic life as are supplied by sculptured stones and inscriptions, and the double discovery of hoards of gold coins, has come to light a spacious and massively constructed stone building, apparently a military storehouse, worthy to rank beside the bridge-piers of the North Tyne, among the most imposing monuments of Roman Britain. There is much here, indeed, to carry our thoughts far beyond our insular limits. On this, as on so many other sites along the Wall, the inscriptions and reliefs take us very far afield. We mark the grave-stone of a man of Palmyra, an altar of the Tyrian Hercules—its Phœnician Baal—a dedication to a pantheistic goddess of Syrian religion and the rayed effigy of the Persian Mithra. So, too, in the neighborhood of Newcastle itself, as elsewhere on the Wall, there was found an altar of Jupiter Dolichenus, the old Anatolian God of the Double Axe, the male form of the divinity once worshipped in the prehistoric Labyrinth of Crete. Nowhere are we more struck than in this remote extremity of the empire with the heterogeneous religious elements, often drawn from its far eastern borders, that before the days of the final advent of Christianity, Roman dominion had been instrumental in diffusing. The Orontes may be said to have flowed into the Tyne as well as the Tiber.

I have no pretension to follow up the various affluents merged in the later course of Greco-Roman civilization, as illustrated by these and similar discoveries throughout the Roman World. My own recent researches have been particularly concerned with the much more ancient cultural stage —that of prehistoric Crete—which leads up to the Greco-Roman, and which might seem to present the problem of origins at any rate in a less complex shape. The marvel-

lous Minoan civilization that has there come to light shows that Crete of four thousand years ago must unquestionably be regarded as the birth-place of our European civilization in its higher form.

But are we, even then, appreciably nearer to the fountain-head?

A new and far more remote vista has opened out in recent years, and it is not too much to say that a wholly new standpoint has been gained from which to survey the early history of the human race. The investigations of a brilliant band of prehistoric archeologists, with the aid of representatives of the sister sciences of geology and paleontology, have brought together such a mass of striking materials as to place the evolution of human art and appliances in the last Quaternary period on a far higher level than had even been suspected previously. Following in the footsteps of Lartet and after him Rivière and Piette, Professors Cartailhac, Captain, and Boule, the Abbé Breuil, Dr. Obermeier and their fellow investigators have revolutionized our knowledge of a phase of human culture which goes so far back beyond the limits of any continuous story, that it may well be said to belong to an older world.

To the engraved and sculptured works of man in the "Reindeer Period" we have now to add not only such new specialties as are exemplified by the moulded clay figures of life-size bisons in the Tuc d'Audoubert Cave, or the similar high reliefs of a procession of six horses cut on the overhanging limestone brow of Cap Blanc, but whole galleries of painted designs on the walls of caverns and rock shelters.

So astonishing was this last discovery, made first by the Spanish investigator Señor de Sautuola—or rather his little daughter—as long ago as 1878, that it was not till after it had been corroborated by repeated finds on the French side of the Pyrenees—not, indeed, till the beginning of the present century—that the Palæolithic Age of these rock paintings was generally recognized. In their most developed stage, as illustrated by the bulk of the figures in the Cave of Altamira itself, and in those of Marsoulas in the Haute Garonne, and of Font de Gaume in the Dordogne, these primeval frescoes display not only a consummate mastery of natural design but an extraordinary technical resource. Apart from the charcoal used in certain outlines, the chief coloring matter was red and yellow ochre, mortars and palettes for the preparation of which have come to light. In single animals the tints are varied from black to dark and ruddy brown or brilliant orange, and so, by fine gradations, to paler nuances, obtained by scraping and washing. Outlines and details are brought out by white incised lines, and the artists availed themselves with great skill of the reliefs afforded by convexities of the rock surface. But the greatest marvel of all is that such polychrome masterpieces as the bisons, standing and couchant, or with limbs huddled together, of the Altamira Cave, were executed on the ceilings of inner vaults and galleries where the light of day has never penetrated. Nowhere is there any trace of smoke, and it is clear that great progress in the art of artificial illumination had already been made. We now know that stone lamps, decorated in one case with the engraved head of an ibex, were already in existence.

Such was the level of artistic attainment in southwestern Europe, at a modest estimate some ten thousand years earlier than the most ancient monuments of Egypt or Chaldæa! Nor is this an isolated phenomenon. One by one, characteristics, both spiritual and material, that had been formerly thought to be the special marks of later ages of mankind have been shown to

go back to that earlier world. I myself can never forget the impression produced on me as a privileged spectator of a freshly uncovered interment in one of the Balzi Rossi Caves—an impression subsequently confirmed by other experiences of similar discoveries in these caves, which together first supplied the concordant testimony of an elaborate cult of the dead on the part of Aurignacian Man. Tall skeletons of the highly developed Cro-Magnon type lay beside or above their hearths, and protected by great stones from roving beasts. Flint knives and bone javelins had been placed within reach of their hands, chaplets and necklaces of sea-shells, fish-vertebræ, and studs of carved bone had decked their persons. With these had been set lumps of iron peroxide, the red stains of which appeared on skulls and bones, so that they might make a fitting show in the underworld.

> Colors, too, to paint his body,
> Place within his hand,
> That he glisten, bright and ruddy,
> In the Spirit-Land! [4]

Nor is it only in this cult of the departed that we trace the dawn of religious practises in that older world. At Cogul we may now survey the ritual dance of nine skirted women round a male satyr-like figure of short stature, while at Alpera a gowned sister ministrant holds up what has all the appearance of being a small idol. It can hardly be doubted that the small female images of ivory, steatite and crystalline talc from the same Aurignacian stratum as that of the Balzi Rossi interments, in which great prominence is given to the organs of maternity, had some fetichistic intention. So, too, many of the figures of animals engraved and painted on the inmost vaults of the caves may well have been due, as M. Salomon Reinach has suggested, to the magical ideas prompted by the desire to obtain a hold on the quarries of the chase that supplied the means of livelihood.

[4] Schiller, "Nadowessier's Todtenlied."

In a similar religious connection may be taken the growth of a whole family of signs, in some cases obviously derivatives of fuller pictorial originals, but not infrequently simplified to such a degree that they resemble or actually reproduce letters of the alphabet. Often they occur in groups like regular inscriptions, and it is not surprising that in some quarters they should have been regarded as evidence that the art of writing had already been evolved by the men of the Reindeer Age. A symbolic value certainly is to be attributed to these signs, and it must at least be admitted that by the close of the late Quaternary Age considerable advance had been made in hieroglyphic expression.

The evidences of more or less continuous civilized development reaching its apogee about the close of the Magdalenian Period have been constantly emerging from recent discoveries. The recurring "tectiform" sign had already clearly pointed to the existence of huts or wigwams; the "scutiform" and other types record appliances yet to be elucidated, and another sign well illustrated on a bone pendant from the Cave of St. Marcel has an unmistakable resemblance to a sledge.[5] But the most astonishing revelation of the cultural level already reached by primeval man has been supplied by the more recently discovered rock paintings of Spain. The area of discovery has now been extended there from the Province of Santander, where Altamira itself is situated, to the Valley of the Ebro, the Central Sierras, and to the extreme

[5] This interpretation suggested by me after inspecting the object in 1902 has been approved by the Abbé Breuil (*Anthropologie*, XIII., p. 152) and by Professor Sollas, "Ancient Hunters," 2 1915, p. 480.

southeastern region, including the Provinces of Albacete, Murcia and Almeria, and even to within the borders of Granada.

One after another, features that had been reckoned as the exclusive property of Neolithic or later Ages are thus seen to have been shared by Palæolithic Man in the final stage of his evolution. For the first time, moreover, we find the productions of his art rich in human subjects. At Cogul the sacral dance is performed by women clad from the waist downwards in well-cut gowns, while in a rock-shelter of Alpera,[6] where we meet with the same skirted ladies, their dress is supplemented by flying sashes. On the rock painting of the Cueva de la Vieja, near the same place, women are seen with still longer gowns rising to their bosoms. We are already a long way from Eve!

It is this great Alpera fresco which, among all those discovered, has afforded most new elements. Here are depicted whole scenes of the chase in which bowmen—up to the time of these last discoveries unknown among Palæolithic representations—take a leading part, though they had not as yet the use of quivers. Some are dancing in the attitude of the Australian Corroborees. Several wear plumed headdresses, and the attitudes at times are extraordinarily animated. What is specially remarkable is that some of the groups of these Spanish-rock paintings show dogs or jackals accompanying the hunters, so that the process of domesticating animals had already begun. Hafted axes are depicted as well as cunningly shaped throwing sticks. In one case at least we see two opposed bands of archers—marking at any rate a stage in social development in which organized warfare was possible—the beginnings, it is to be feared, of "Kultur" as well as of culture!

[6] That of Carasoles del Bosque; Breuil, *Anthropologie*, XXVI., 1915, p. 329 seqq.

Nor can there be any question as to the age of these scenes and figures, by themselves so suggestive of a much later phase of human history. They are inseparable from other elements of the same group, the animal and symbolic representations of which are shared by the contemporary school of rock-painting north of the Pyrenees. Some are overlaid by palimpsests, themselves of Palæolithic character. Among the animals actually depicted, moreover, the elk and bison distinctly belong to the Late Quaternary fauna of both regions, and are unknown there to the Neolithic deposits.

In its broader aspects this field of human culture, to which, on the European side, the name of Reindeer Age may still, on the whole, be applied, is now seen to have been very widespread. In Europe itself it permeates a large area—defined by the boundaries of glaciation—from Poland, and even a large Russian tract, to Bohemia, the upper course of the Danube and of the Rhine, to southwestern Britain and southeastern Spain. Beyond the Mediterranean, moreover, it fits on under varying conditions to a parallel form of culture, the remains of which are by no means confined to the Cis-Saharan zone, where incised figures occur of animals like the long-horned buffalo (*Bulbalus antiquus*) and others long extinct in that region. This southern branch may eventually be found to have a large extension. The nearest parallels to the finer class of rock-carvings as seen in the Dordogne are, in fact, to be found among the more ancient specimens of similar work in South Africa, while the rock-paintings of Spain find their best analogies among the Bushmen.

Glancing at this Late Quaternary culture, as a whole, in view of the materials supplied on the European side, it will not be superfluous for me to call attention to

two important points which some observers have shown a tendency to pass over.

Its successive phases, the Aurignacian, the Solutrean and the Magdalenian, with its decadent Azilian offshoot—the order of which may now be regarded as stratigraphically established—represent, on the whole, a continuous story.

I will not here discuss the question as to how far the disappearance of Neanderthal Man and the close of the Moustierian epoch represents a "fault" or gap. But the view that there was any real break in the course of the cultural history of the Reindeer Age itself does not seem to have sufficient warrant.

It is true that new elements came in from more than one direction. On the old Aurignacian area, which had a trans-Mediterranean extension from Syria to Morocco, there intruded on the European side—apparently from the east—the Solutrean type of culture, with its perfected flint-working and exquisite laurel-leaf points. Magdalenian man, on the other hand, great as the proficiency that he attained in the carving of horn and bone, was much behind in his flint-knapping. That there were dislocations and temporary set-backs is evident. But on every side we still note transitions and reminiscences. When, moreover, we turn to the most striking features of this whole cultural phase, the primeval arts of sculpture, engraving and painting, we see a gradual upgrowth and unbroken tradition. From mere outline figures and simple two-legged profiles of animals we are led on step by step to the full freedom of the Magdalenian artists. From isolated or disconnected subjects we watch the advance to large compositions, such as the hunting scenes of the Spanish rock-paintings. In the culminating phase of this art we even find impressionist works. A brilliant illustration of such is seen in the galloping herds of horses, lightly sketched by the engraver on the stone slab from the Chaumont Grotto, depicting the leader in each case in front of his troop, and its serried line—straight as that of a well-drilled battalion—in perspective rendering. The whole must be taken to be a faithful memory sketch of an exciting episode of prairie life.

The other characteristic feature of the culture of the Reindeer age that seems to deserve special emphasis, and is almost the corollary of the foregoing, is that it can not be regarded as the property of a single race. It is true that the finely built Cro-Magnon race seems to have predominated, and must be regarded as an element of continuity throughout, but the evidence of the co-existence of other human types is clear. Of the physical characteristics of these it is not my province to speak. Here it will be sufficient to point out that their interments, as well as their general associations, conclusively show that they shared, even in its details, the common culture of the age, followed the same fashions, plied the same arts, and were imbued with the same beliefs as the Cro-Magnon folk. The negroid skeletons intercalated in the interesting succession of hearths and interments of the Grotte des Enfants at Grimaldi had been buried with the same rites, decked with the same shell ornaments, and were supplied with the same red coloring matter for use in the spirit world, as we find in the other sepultures of these caves belonging to the Cro-Magnon race. Similar burial rites were associated in this country with the "Red Lady of Paviland," the contemporary Aurignacian date of which is now well established. A like identity of funeral custom recurred again in the sepulture of a man of the "Brünn" race on the eastern boundary of this field of culture.

In other words, the conditions prevailing were analogous to those of modern Europe. Cultural features of the same general char-

acter had imposed themselves on a heterogeneous population. That there was a considerable amount of circulation, indeed—if not of primitive commerce—among the peoples of the Reindeer Age is shown by the diffusion of shell or fossil ornaments derived from the Atlantic, the Mediterranean or from inland geological strata. Art itself is less the property of one or another race than has sometimes been imagined—indeed, if we compare those products of the modern carver's art that have most analogy with the horn and bone carvings of the Cave Men and rise at times to great excellence—as we see them, for instance, in Switzerland or Norway—they are often the work of races of very different physical types. The negroid contributions, at least in the southern zone of this Late Quaternary field, must not be underestimated. The early steatopygous images—such as some of these of the Balzi Rossi caves—may safely be regarded as due to this ethnic type, which is also pictorially represented in some of the Spanish rock-paintings.

The nascent flame of primeval culture was thus already kindled in that older world, and, so far as our present knowledge goes, it was in the southwestern part of our continent, on either side of the Pyrenees, that it shone its brightest. After the great strides in human progress already made at that remote epoch, it is hard, indeed, to understand what it was that still delayed the rise of European civilization in its higher shape. Yet it had to wait for its fulfilment through many millennia. The gathering shadows thickened and the darkness of a long night fell not on that favored region alone, but throughout the wide area where Reindeer Man had ranged. Still the question rises—as yet imperfectly answered—were there no relay runners to pass on elsewhere the lighted torch?

Something, indeed, has been recently done towards bridging over the "hiatus" that formerly separated the Neolithic from the Palæolithic Age—the yawning gulf between two worlds of human existence. The Azilian—a later decadent outgrowth of the preceding culture—which is now seen partially to fill the lacuna, seems to be in some respects an impoverished survival of the Aurignacian.[7] The existence of this phase was first established by the long and patient investigations of Piette in the stratified deposits of the cave of Mas d'Azil in the Ariège, from which it derives its name, and it has been proved by recent discoveries to have had a wide extension. It affords evidence of a milder and moister climate—well illustrated by the abundance of the little wood snail (*helix nemoralis*) and the increasing tendency of the reindeer to die out in the southern parts of the area, so that in the fabric of the characteristic harpoons deer-horns are used as substitutes. Artistic designs now fail us, but the polychrome technique of the preceding age still survives in certain schematic and geometric figures, and in curious colored signs on pebbles. These last first came to light in the cave of Mas d'Azil, but they have now been found to recur much further afield in a similar association in grottoes from the neighborhood of Basel to that of Salamanca. So like letters are some of these signs that the lively imagination of Piette saw in them the actual characters of a primeval alphabet!

The little flakes with a worked edge often known as "pygmy flints," which were most of them designed for insertion into bone or horn harpoons, like some Neolithic examples, are very characteristic of this stratum, which is widely diffused in France and elsewhere under the misleading name of "Tardenoisian." At Ofnet, in Bavaria, it is associated with a ceremonial skull

[7] Breuil, "Congr. Préhist.," Geneva, 1912, p. 216.

burial showing the coexistence at that spot of brachycephalic and dolichocephalic types, both of a new character. In Britain, as we know, this Azilian, or a closely allied phase, is traceable as far north as the Oban Caves.

What, however, is of special interest is the existence of a northern parallel to this cultural phase, first ascertained by the Danish investigator, Dr. Sarauw, in the lake station of Maglemose, near the west coast of Zealand. Here bone harpoons of the Azilian type occur, with bone and horn implements showing geometrical and rude animal engravings of a character divergent from the Magdalenian tradition. The settlement took place when what is now the Baltic was still the great "Ancylus Lake," and the waters of the North Sea had not yet burst into it. It belongs to the period of the Danish pine and birch woods, and is shown to be anterior to the earliest shell mounds of the Kitchenmidden people, when the pine and the birch had given place to the oak. Similar deposits extend to Sweden and Norway, and to the Baltic provinces as far as the Gulf of Finland. The parallel relationship of this culture is clear, and its remains are often accompanied with the characteristic "pygmy" flints. Breuil, however,[8] while admitting the late Palæolithic character of this northern branch, would bring it into relation with a vast Siberian and Altaic province, distinguished by the widespread existence of rock-carvings of animals. It is interesting to note that a rock-engraving of a reindeer, very well stylized, from the Trondhjem Fjord, which has been referred to the Maglemosian phase, preserves the simple profile rendering—two legs only being visible—of Early Aurignacian tradition.

[8] "Les subdivisions du paléolithique supérieur et leur signification." Congrès intern. d'Anthrop. et d'Archéol. préhist., XIV[me] Sess., Genève, 1912, pp. 165, 238.

It is worth noting that an art affiliated to that of the petroglyphs of the old Altaic region long survived in the figures of the Lapp trolldrums, and still occasionally lingers, as I have myself had occasion to observe, on the reindeer-horn spoons of the Finnish and Russian Lapps, whose ethnic relationship, moreover, points east of the Urals. The existence of a Late Palæolithic Province on the Russian side is in any case now well recognized and itself supports the idea of a later shifting north and northeast, just as at a former period it had oscillated in a southwestern direction. All this must be regarded as corroborating the view long ago expressed by Boyd Dawkins[9] that some part of the old cave race may still be represented by the modern Eskimos. Testut's comparison of the short-statured Magdalenian skeleton from the rock shelter of Chancelade in the Dordogne with that of an Eskimo certainly confirms this conclusion.

On the other hand, the evidence, already referred to, of an extension of the Late Palæolithic culture to a North African zone, including rock-sculptures depicting a series of animals extinct there in the later age, may be taken to favor the idea of a partial continuation on that side. Some of the early rock-sculptures in the south of the continent, such as the figure of a walking elephant reproduced by Dr. Peringuey, afford the clearest existing parallels to the best Magdalenian examples. There is much, indeed, to be said for the view, of which Sollas is an exponent, that the bushmen, who at a more recent date entered that region from the north, and whose rock-painting attained such a high level of naturalistic art, may themselves be taken as later representatives of the same tradition. In their human figures the resemblances descend even to conventional details, such as we meet with at Cogul and Alpera.

[9] "Early Man in Britain," 1880, p. 233 seqq.

Once more, we must never lose sight of the fact that from the Early Aurignacian Period onwards a negroid element in the broadest sense of the word shared in this artistic culture as seen on both sides of the Pyrenees.

At least we now know that cave man did not suffer any sudden extinction, though on the European side, partly, perhaps, owing to the new climatic conditions, this culture underwent a marked degeneration. It may well be that, as the osteological evidence seems to imply, some outgrowth of the old Cro-Magnon type actually perpetuated itself in the Dordogne. We have certainly lengthened our knowledge of the Palæolithic. But in the present state of the evidence it seems better to subscribe to Cartailhac's view that its junction with the Neolithic has not yet been reached. There does not seem to be any real continuity between the culture revealed at Maglemose and that of the immediately superposed Early Neolithic stratum of the shell-mounds, which, moreover, as has been already said, evidence a change both in climatic and geological conditions, implying a considerable interval of time.

ARTHUR EVANS
UNIVERSITY OF OXFORD

(To be continued)

THE ORGANIZATION OF THOUGHT[1]

THE subject of this address is the organization of thought, a topic evidently capable of many diverse modes of treatment. I intend more particularly to give some account of that department of logical science with which some of my own studies have been connected. But I am anxious, if I can succeed in so doing, to handle this account so as to exhibit the relation with certain considerations which underlie general scientific activities.

It is no accident that an age of science has developed into an age of organization. Organized thought is the basis of organized action. Organization is the adjustment of diverse elements so that their mutual relations may exhibit some predetermined quality. An epic poem is a triumph of organization, that is to say, it is a triumph in the unlikely event of it being a good epic poem. It is the successful organization of multitudinous sounds of words, associations of words, pictorial memories of diverse events and feelings ordinarily occurring in life, combined with a special narrative of great events: the whole so disposed as to excite emotions which, as defined by Milton, are simple, sensuous and passionate. The number of successful epic poems is commensurate, or rather, is inversely commensurate with the obvious difficulty of the task of organization.

Science is the organization of thought. But the example of the epic poem warns us that science is not any organization of thought. It is an organization of a certain definite type which we will endeavor to determine.

Science is a river with two sources, the practical source and the theoretical source. The practical source is the desire to direct our actions to achieve predetermined ends. For example, the British nation, fighting for justice, turns to science, which teaches it the importance of compounds of nitrogen. The theoretical source is the desire to understand. Now I am going to emphasize the importance of theory in science. But to avoid misconception I most emphatically state that I do not consider one source as in any sense nobler than the other, or intrinsically more interesting. I can not see why it is nobler to strive to understand than to busy oneself with the right ordering of one's

[1] Address of the president of the Mathematical and Physical Science Section, British Association for the Advancement of Science, Newcastle-on-Tyne, 1916.

actions. Both have their bad sides; there are evil ends directing actions, and there are ignoble curiosities of the understanding.

The importance, even in practise, of the theoretical side of science arises from the fact that action must be immediate, and takes place under circumstances which are excessively complicated. If we wait for the necessities of action before we commence to arrange our ideas, in peace we shall have lost our trade, and in war we shall have lost the battle.

Success in practise depends on theorists who, led by other motives of exploration, have been there before, and by some good chance have hit upon the relevant ideas. By a theorist I do not mean a man who is up in the clouds, but a man whose motive for thought is the desire to formulate correctly the rules according to which events occur. A successful theorist should be excessively interested in immediate events, otherwise he is not at all likely to formulate correctly anything about them. Of course, both sources of science exist in all men.

Now, what is this thought organization which we call science? The first aspect of modern science which struck thoughtful observers was its inductive character. The nature of induction, its importance, and the rules of inductive logic have been considered by a long series of thinkers, especially English thinkers, Bacon, Herschel, J. S. Mill, Venn, Jevons and others. I am not going to plunge into an analysis of the process of induction. Induction is the machinery and not the product, and it is the product which I want to consider. When we understand the product we shall be in a stronger position to improve the machinery.

First, there is one point which it is necessary to emphasize. There is a tendency in analyzing scientific processes to assume a given assemblage of concepts applying to nature, and to imagine that the discovery of laws of nature consists in selecting by means of inductive logic some one out of a definite set of possible alternative relations which may hold between the things in nature answering to these obvious concepts. In a sense this assumption is fairly correct, especially in regard to the earlier stages of science. Mankind found itself in possession of certain concepts respecting nature—for example, the concept of fairly permanent material bodies—and proceeded to determine laws which related the corresponding percepts in nature. But the formulation of laws changed the concepts, sometimes gently by an added precision, sometimes violently. At first this process was not much noticed, or at least was felt to be a process curbed within narrow bounds, not touching fundamental ideas. At the stage where we now are, the formulation of the concepts can be seen to be as important as the formulation of the empirical laws connecting the events in the universe as thus conceived by us. For example, the concepts of life, of heredity, of a material body, of a molecule, of an atom, of an electron, of energy, of space, of time, of quantity, and of number. I am not dogmatizing about the best way of getting such ideas straight. Certainly it will only be done by those who have devoted themselves to a special study of the facts in question. Success is never absolute, and progress in the right direction is the result of a slow, gradual process of continual comparison of ideas with facts. The criterion of success is that we should be able to formulate empirical laws, that is, statements of relations, connecting the various parts of the universe as thus conceived, laws with the property that we can interpret the actual events of our lives as being our fragmentary knowledge of this conceived interrelated whole.

But, for the purposes of science, what is the actual world? Has science to wait for the termination of the metaphysical debate till it can determine its own subject-matter? I suggest that science has a much more homely starting-ground. Its task is the discovery of the relations which exist within that flux of perceptions, sensations and emotions which forms our experience of life. The panorama yielded by sight, sound, taste, smell, touch and by more inchoate sensible feelings, is the sole field of its activity. It is in this way that science is the thought organization of experience. The most obvious aspect of this field of actual experience is its disorderly character. It is for each person a *continuum*, fragmentary, and with elements not clearly differentiated. The comparison of the sensible experiences of diverse people brings its own difficulties. I insist on the radically untidy, ill-adjusted character of the fields of actual experience from which science starts. To grasp this fundamental truth is the first step in wisdom, when constructing a philosophy of science. This fact is concealed by the influence of language, moulded by science, which foists on us exact concepts as though they represented the immediate deliverances of experience. The result is that we imagine that we have immediate experience of a world of perfectly defined objects implicated in perfectly defined events which, as known to us by the direct deliverance of our senses, happen at exact instants of time, in a space formed by exact points, without parts and without magnitude: the neat, trim, tidy, exact world which is the goal of scientific thought.

My contention is that this world is a world of ideas, and that its internal relations are relations between abstract concepts, and that the elucidation of the precise connection between this world and the feelings of actual experience is the fundamental question of scientific philosophy. The question which I am inviting you to consider is this: How does exact thought apply to the fragmentary, vague *continua* of experience? I am not saying that it does not apply, quite the contrary. But I want to know how it applies. The solution I am asking for is not a phrase, however brilliant, but a solid branch of science, constructed with slow patience, showing in detail how the correspondence is effected.

The first great steps in the organization of thought were due exclusively to the practical source of scientific activity, without any admixture of theoretical impulse. Their slow accomplishment was the cause and also the effect of the gradual evolution of moderately rational beings. I mean the formation of the concepts of definite material objects, of the determinate lapse of time, of simultaneity, of recurrence, of definite relative position, and of analogous fundamental ideas, according to which the flux of our experiences is mentally arranged for handy reference: in fact, the whole apparatus of common-sense thought. Consider in your mind some definite chair. The concept of that chair is simply the concept of all the interrelated experiences connected with that chair—namely, of the experiences of the folk who made it, of the folk who sold it, of the folk who have seen it, or used it, of the man who is now experiencing a comfortable sense of support, combined with our expectations of an analogous future, terminated finally by a different set of experiences when the chair collapses and becomes fire-wood. The formation of that type of concept was a tremendous job, and zoologists and geologists tell us that it took many tens of millions of years. I can well believe it.

I now emphasize two points. In the first

place, science is rooted in what I have just called the whole apparatus of common-sense thought. That is the *datum* from which it starts, and to which it must recur. We may speculate, if it amuses us, of other beings in other planets who have arranged analogous experiences according to an entirely different conceptual code—namely, who have directed their chief attention to different relations between their various experiences. But the task is too complex, too gigantic, to be revised in its main outlines. You may polish up common sense, you may contradict it in detail, you may surprise it. But ultimately your whole task is to satisfy it.

In the second place, neither common sense nor science can proceed with their task of thought organization without departing in some respect from the strict consideration of what is actual in experience. Think again of the chair. Among the experiences upon which its concept is based, I included our expectations of its future history. I should have gone further and included our imagination of all the possible experiences which in ordinary language we should call perceptions of the chair which might have occurred. This is a difficult question, and I do not see my way through it. But at present in the construction of a theory of space and of time, there seem insuperable difficulties if we refuse to admit ideal experiences.

This imaginative perception of experiences, which, if they occurred, would be coherent with our actual experiences, seems fundamental in our lives. It is neither wholly arbitrary, nor yet fully determined. It is a vague background which is only made in part definite by isolated activities of thought. Consider, for example, our thoughts of the unseen flora of Brazil.

Ideal experiences are closely connected with our imaginative reproduction of the actual experiences of other people, and also with our almost inevitable conception of ourselves as receiving our impressions from an external complex reality beyond ourselves. It may be that an adequate analysis of every source and every type of experience yields demonstrative proof of such a reality and of its nature. Indeed, it is hardly to be doubted that this is the case. The precise elucidation of this question is the problem of metaphysics. One of the points which I am urging in this address is that the basis of science does not depend on the assumption of any of the conclusions of metaphysics; but that both science and metaphysics start from the same given groundwork of immediate experience, and in the main proceed in opposite directions on their diverse tasks.

For example, metaphysics inquires how our perceptions of the chair relate us to some true reality. Science gathers up these perceptions into a determinate class, adds to them ideal perceptions of analogous sort, which under assignable circumstances would be obtained, and this single concept of that set of perceptions is all that science needs; unless indeed you prefer that thought find its origin in some legend of those great twin brethren, the cock and bull.

My immediate problem is to inquire into the nature of the texture of science. Science is essentially logical. The nexus between its concepts is a logical nexus, and the grounds for its detailed assertions are logical grounds. King James said, "No bishops, no king." With greater confidence we can say, "No logic, no science." The reason for the instinctive dislike which most men of science feel towards the recognition of this truth is, I think, the barren failure of logical theory during the past three or four centuries. We may trace this failure back to the worship of authority

which in some respects increased in the learned world at the time of the Renaissance. Mankind then changed its authority, and this fact temporarily acted as an emancipation. But the main fact, and we can find complaints[2] of it at the very commencement of the modern movement, was the establishment of a reverential attitude towards any statement made by a classical author. Scholars became commentators on truths too fragile to bear translation. A science which hesitates to forget its founders is lost. To this hesitation I ascribe the barrenness of logic. Another reason for distrust of logical theory and of mathematics is the belief that deductive reasoning can give you nothing new. Your conclusions are contained in your premises, which by hypothesis are known to you.

In the first place this last condemnation of logic neglects the fragmentary, disconnected character of human knowledge. To know one premise on Monday, and another premise on Tuesday, is useless to you on Wednesday. Science is a permanent record of premises, deductions and conclusions, verified all along the line by its correspondence with facts. Secondly, it is untrue that when we know the premises we also know the conclusions. In arithmetic, for example, mankind are not calculating boys. Any theory which proves that they are conversant with the consequences of their assumptions must be wrong. We can imagine beings who possess such insight. But we are not such creatures. Both these answers are, I think, true and relevant. But they are not satisfactory. They are too much in the nature of bludgeons, too external. We want something more explanatory of the very real difficulty which the question suggests. In fact, the true answer is embedded in the discussion of our main problem of the relation of logic to natural science.

[2] *E. g.*, in 1551 by Italian schoolmen.

It will be necessary to sketch in broad outline some relevant features of modern logic. In doing so I shall try to avoid the profound general discussions and the minute technical classifications which occupy the main part of traditional logic. It is characteristic of a science in its earlier stages—and logic has become fossilized in such a stage—to be both ambitiously profound in its aims and trivial in its handling of details. We can discern four departments of logical theory. By an analogy which is not so very remote I will call these departments or sections the arithmetic section, the algebraic section, the section of general-function theory, the analytic section. I do not mean that arithmetic arises in the first section, algebra in the second section, and so on; but the names are suggestive of certain qualities of thought in each section which are reminiscent of analogous qualities in arithmetic, in algebra, in the general theory of a mathematical function, and in the analysis of the properties of particular functions.

The first section—namely, the arithmetic stage—deals with the relations of definite propositions to each other, just as arithmetic deals with definite numbers. Consider any definite proposition; call it "*p*." We conceive that there is always another proposition which is the direct contradictory to "*p*"; call it "not-*p*." When we have got two propositions, *p* and *q*, we can form derivative propositions from them, and from their contradictories. We can say, "At least one of *p* or *q* is true, and perhaps both." Let us call this proposition "*p* or *q*." I may mention as an aside that one of the greatest living philosophers has stated that this use of the word "or"—namely, "*p* or *q*" in the sense that either or both may be true—makes him despair of

exact expression. We must brave his wrath, which is unintelligible to me.

We have thus got hold of four new propositions, namely, "*p* or *q*," and "not-*p* or *q*," and "*p* or not-*q*," and "not-*p* or not-*q*." Call these the set of disjunctive derivatives. There are, so far, in all eight propositions *p*, not-*p*, *q*, not-*q*, and the four disjunctive derivatives. Any pair of these eight propositions can be taken, and substituted for *p* and *q* in the foregoing treatment. Thus each pair yields eight propositions, some of which may have been obtained before. By proceeding in this way we arrive at an unending set of propositions of growing complexity, ultimately derived from the two original propositions *p* or *q*. Of course, only a few are important. Similarly we can start from three propositions, *p*, *q*, *r*, or from four propositions, *p*, *q*, *r*, *s*, and so on. Any one of the propositions of these aggregates may be true or false. It has no other alternative. Whichever it is, true or false, call it the "truth-value" of the proposition.

The first section of logical inquiry is to settle what we know of the truth-values of these propositions, when we know the truth-values of some of them. The inquiry, so far as it is worth while carrying it, is not very abstruse, and the best way of expressing its results is a detail which I will not now consider. This inquiry forms the arithmetic stage.

The next section of logic is the algebraic stage. Now, the difference between arithmetic and algebra is that in arithmetic definite numbers are considered, and in algebra symbols—namely, letters—are introduced which stand for any numbers. The idea of a number is also enlarged. These letters, standing for any numbers, are called sometimes variables and sometimes parameters. Their essential characteristic is that they are undetermined, unless, indeed, the algebraic conditions which they satisfy implicitly determine them. Then they are sometimes called unknowns. An algebraic formula with letters is a blank form. It becomes a determinate arithmetic statement when definite numbers are substituted for the letters. The importance of algebra is a tribute to the study of form. Consider now the following proposition,

The specific heat of mercury is 0.033.

This is a definite proposition which, with certain limitations, is true. But the truth-value of the proposition does not immediately concern us. Instead of mercury put a mere letter which is the name of some undetermined thing: we get

The specific heat of x is 0.033.

This is not a proposition; it has been called by Russell a propositional function. It is the logical analogy of an algebraic expression. Let us write $f(x)$ for any propositional function.

We could also generalize still further, and say

The specific heat of x is y.

We thus get another propositional function, $F(x, y)$ of two arguments x and y, and so on for any number of arguments.

Now, consider $f(x)$. There is the range of values of x, for which $f(x)$ is a proposition, true or false. For values of x outside this range, $f(x)$ is not a proposition at all, and is neither true nor false. It may have vague suggestions for us, but it has no unit meaning of definite assertion. For example,

The specific heat of water is 0.033

is a proposition which is false; and

The specific heat of virtue is 0.033

is, I should imagine, not a proposition at all; so that it is neither true nor false, though its component parts raise various associations in our minds. This range of values, for which $f(x)$ has sense, is called the "type" of the argument x.

But there is also a range of values of x for which $f(x)$ is a true proposition. This is the class of those values of the argument which *satisfy* $f(x)$. This class may have no members, or, in the other extreme, the class may be the whole type of the arguments.

We thus conceive two general propositions respecting the indefinite number of propositions which share in the same logical form, that is, which are values of the same propositional function. One of these propositions is

$f(x)$ yields a true proposition for each value of x of the proper type;

the other proposition is

There is a value of x for which $f(x)$ is true.

Given two, or more, propositional functions $f(x)$ and $\phi(x)$ with the same argument x, we form derivative propositional functions, namely,

$$f(x) \text{ or } \phi(x),\ f(x) \text{ or not-}\phi(x),$$

and so on with the contradictories, obtaining, as in the arithmetical stage, an unending aggregate of propositional functions. Also each propositional function yields two general propositions. The theory of the interconnection between the truth-values of the general propositions arising from any such aggregate of propositional functions forms a simple and elegant chapter of mathematical logic.

In this algebraic section of logic the theory of types crops up, as we have already noted. It can not be neglected without the introduction of error. Its theory has to be settled at least by some safe hypothesis, even if it does not go to the philosophic basis of the question. This part of the subject is obscure and difficult, and has not been finally elucidated, though Russell's brilliant work has opened out the subject.

The final impulse to modern logic comes from the independent discovery of the importance of the logical variable by Frege and Peano. Frege went further than Peano, but by an unfortunate symbolism rendered his work so obscure that no one fully recognized his meaning who had not found it out for himself. But the movement has a large history reaching back to Leibniz and even to Aristotle. Among English contributors are De Morgan, Boole and Sir Alfred Kempe; their work is of the first rank.

The third logical section is the stage of general-function theory. In logical language, we perform in this stage the transition from intension to extension, and investigate the theory of denotation. Take the propositional function $f(x)$. There is the class, or range of values for x, whose members satisfy $f(x)$. But the same range may be the class whose members satisfy another propositional function $\phi(x)$. It is necessary to investigate how to indicate the class by a way which is indifferent as between the various propositional functions which are satisfied by any member of it, and of it only. What has to be done is to analyze the nature of propositions about a class—namely, those propositions whose truth-values depend on the class itself and not on the particular meaning by which the class is indicated.

Furthermore, there are propositions about alleged individuals indicated by descriptive phrases: for example, propositions about "the present King of England," who does exist, and "the present Emperor of Brazil," who does not exist. More complicated, but analogous, questions involving propositional functions of two variables involve the notion of "correlation," just as functions of one argument involve classes. Similarly functions of three arguments yield three-cornered correlations, and so on. This logical section is one which Russell has made peculiarly his own by work which must always remain fundamental. I have

called this the section of functional theory, because its ideas are essential to the construction of logical denoting functions which include as a special case ordinary mathematical functions such as sine, logarithm, etc. In each of these three stages it will be necessary gradually to introduce an appropriate symbolism, if we are to pass on to the fourth stage.

The fourth logical section, the analytic stage, is concerned with the investigation of the properties of special logical constructions, that is, of classes and correlations of special sorts. The whole of mathematics is included here. So the section is a large one. In fact, it is mathematics, neither more nor less. But it includes an analysis of mathematical ideas not hitherto included in the scope of that science, nor, indeed, contemplated at all. The essence of this stage is construction. It is by means of suitable constructions that the great framework of applied mathematics, comprising the theories of number, quantity, time and space, is elaborated.

It is impossible even in brief outline to explain how mathematics is developed from the concepts of class and correlation, including many-cornered correlations, which are established in the third section. I can only allude to the headings of the process which is fully developed in the work, "Mathematica Principia," by Mr. Russell and myself. There are in this process of development seven special sorts of correlations which are of peculiar interest. The first sort comprises one-to-many, many-to-one, and one-to-one correlations. The second sort comprises serial relations, that is, correlations by which the members of some field are arranged in a serial order, so that, in the sense defined by the relation, any member of the field is either before or after any other member. The third class comprises inductive relations, that is, correlations on which the theory of mathematical induction depends. The fourth class comprises selective relations, which are required for the general theory of arithmetic operations, and elsewhere. It is in connection with such relations that the famous multiplicative axiom arises for consideration. The fifth class comprises vector relations, from which the theory of quantity arises. The sixth class comprises ratio relations, which interconnect number and quantity. The seventh class comprises three-cornered and four-cornered relations which occur in geometry.

A bare enumeration of technical names, such as the above, is not very illuminating, though it may help to a comprehension of the demarcations of the subject. Please remember that the names are technical names, meant, no doubt, to be suggestive, but used in strictly defined senses. We have suffered much from critics who consider it sufficient to criticize our procedure on the slender basis of a knowledge of the dictionary meanings of such terms. For example, a one-to-one correlation depends on the notion of a class with only one member, and this notion is defined without appeal to the concept of the number one. The notion of diversity is all that is wanted. Thus the class α has only one member, if (1) the class of values of x which satisfies the propositional function,

x is not a member of α,

is not the whole type of relevant values of x, and (2) the propositional function,

x and y are members of α, and

x is diverse from y,

is false whatever be the values of x and y in the relevant type.

Analogous procedures are obviously possible for higher finite cardinal members. Thus, step by step, the whole cycle of current mathematical ideas is capable of logical definition. The process is detailed and laborious, and, like all science, knows noth-

ing of a royal road of airy phrases. The essence of the process is, first to construct the notion in terms of the forms of propositions, that is, in terms of the relevant propositional functions, and secondly to prove the fundamental truths which hold about the notion by reference to the results obtained in the algebraic section of logic.

It will be seen that in this process the whole apparatus of special indefinable mathematical concepts, and special *a priori* mathematical premises, respecting number, quantity and space, has vanished. Mathematics is merely an apparatus for analyzing the deductions which can be drawn from any particular premises, supplied by common sense, or by more refined scientific observation, so far as these deductions depend on the forms of the propositions. Propositions of certain forms are continually occurring in thought. Our existing mathematics is the analysis of deductions, which concern those forms and in some way are important, either from practical utility or theoretical interest. Here I am speaking of the science as it in fact exists. A theoretical definition of mathematics must include in its scope any deductions depending on the mere forms of propositions. But, of course, no one would wish to develop that part of mathematics which in no sense is of importance.

This hasty summary of logical ideas suggests some reflections. The question arises, How many forms of propositions are there? The answer is: An unending number. The reason for the supposed sterility of logical science can thus be discerned. Aristotle founded the science by conceiving the idea of the form of a proposition, and by conceiving deduction as taking place in virtue of the forms. But he confined propositions to four forms, now named A, I, E, O. So long as logicians were obsessed by this unfortunate restriction, real progress was impossible. Again, in their theory of form, both Aristotle and subsequent logicians came very near to the theory of the logical variable. But to come very near to a true theory, and to grasp its precise application, are two very different things, as the history of science teaches us. Everything of importance has been said before by somebody who did not discover it.

Again, one reason why logical deductions are not obvious is that logical form is not a subject which ordinarily enters into thought. Common-sense deduction probably moves by blind instinct from concrete proposition to concrete proposition, guided by some habitual association of ideas. Thus common sense fails in the presence of a wealth of material.

A more important question is the relation of induction, based on observation, to deductive logic. There is a tradition of opposition between adherents of induction and of deduction. In my view, it would be just as sensible for the two ends of a worm to quarrel. Both observation and deduction are necessary for any knowledge worth having. We can not get an inductive law without having recourse to a propositional function. For example, take the statement of observed fact,

This body is mercury, and its specific heat is 0.033.

The propositional function is formed,

Either x is not mercury, or its specific heat is 0.033.

The inductive law is the assumption of the truth of the general proposition, that the above propositional function is true for every value of x in the relevant type.

But it is objected that this process and its consequences are so simple that an elaborate science is out of place. In the same way, a British sailor knows the salt sea when he sails over it. What, then, is the use of an elaborate chemical analysis of sea-water? There is the general answer, that you can not know too much of meth-

ods which you always employ; and there is the special answer, that logical forms and logical implications are not so very simple, and that the whole of mathematics is evidence to this effect.

One great use of the study of logical method is not in the region of elaborate deduction, but to guide us in the study of the formation of the main concepts of science. Consider geometry, for example. What are the points which compose space? Euclid tells us that they are without parts and without magnitude. But how is the notion of a point derived from the sense-perceptions from which science starts? Certainly points are not direct deliverances of the senses. Here and there we may see or unpleasantly feel something suggestive of a point. But this is a rare phenomenon, and certainly does not warrant the conception of space as composed of points. Our knowledge of space properties is not based on any observations of relations between points. It arises from experience of relations between bodies. Now a fundamental space relation between bodies is that one body may be part of another. We are tempted to define the "whole and part" relation by saying that the points occupied by the part are some of the points occupied by the whole. But "whole and part" being more fundamental than the notion of "point," this definition is really circular and vicious.

We accordingly ask whether any other definition of "spatial whole and part" can be given. I think that it can be done in this way, though, if I be mistaken, it is unessential to my general argument. We have come to the conclusion that an extended body is nothing else than the class of perceptions of it by all its percipients, actual or ideal. Of course, it is not any class of perceptions, but a certain definite sort of class which I have not defined here, except by the vicious method of saying that they are perceptions of a body. Now, the perceptions of a part of a body are among the perceptions which compose the whole body. Thus two bodies a and b are both classes of perceptions; and b is part of a when the class which is b is contained in the class which is a. It immediately follows from the logical form of this definition that if b is part of a, and c is part of b, then c is part of a. Thus the relation "whole to part" is transitive. Again, it will be convenient to allow that a body is part of itself. This is a mere question of how you draw the definition. With this understanding, the relation is reflexive. Finally, if a is part of b, and b is part of a, then a and b must be identical. These properties of "whole and part" are not fresh assumptions, they follow from the logical form of our definition.

One assumption has to be made if we assume the ideal infinite divisibility of space. Namely, we assume that every class of perceptions which is an extended body contains other classes of perceptions which are extended bodies diverse from itself. This assumption makes rather a large draft on the theory of ideal perceptions. Geometry vanishes unless in some form you make it. The assumption is not peculiar to my exposition.

It is then possible to define what we mean by a point. A point is the class of extended objects which, in ordinary language, contain that point. The definition, without presupposing the idea of a point, is rather elaborate, and I have not now time for its statement.

The advantage of introducing points into geometry is the simplicity of the logical expression of their mutual relations. For science, simplicity of definition is of slight importance, but simplicity of mutual relations is essential. Another example of this law is the way physicists and chemists

have dissolved the simple idea of an extended body, say of a chair, which a child understands, into a bewildering notion of a complex dance of molecules and atoms and electrons and waves of light. They have thereby gained notions with simpler logical relations.

Space as thus conceived is the exact formulation of the properties of the apparent space of the common-sense world of experience. It is not necessarily the best mode of conceiving the space of the physicist. The one essential requisite is that the correspondence between the common-sense world in its space and the physicists' world in its space should be definite and reciprocal.

I will now break off the exposition of the function of logic in connection with the science of natural phenomena. I have endeavored to exhibit it as the organizing principle, analyzing the derivation of the concepts from the immediate phenomena, examining the structure of the general propositions which are the assumed laws of nature, establishing their relations to each other in respect to reciprocal implications, deducing the phenomena we may expect under given circumstances.

Logic, properly used, does not shackle thought. It gives freedom and, above all, boldness. Illogical thought hesitates to draw conclusions, because it never knows either what it means, or what it assumes, or how far it trusts its own assumptions, or what will be the effect of any modification of assumptions. Also the mind untrained in that part of constructive logic which is relevant to the subject in hand will be ignorant of the sort of conclusions which follow from various sorts of assumptions, and will be correspondingly dull in divining the inductive laws. The fundamental training in this relevant logic is, undoubtedly, to ponder with an active mind over the known facts of the case, directly observed. But where elaborate deductions are possible, this mental activity requires for its full exercise the direct study of the abstract logical relations. This is applied mathematics.

Neither logic without observation, nor observation without logic, can move one step in the formation of science. We may conceive humanity as engaged in an internecine conflict between youth and age. Youth is not defined by years, but by the creative impulse to make something. The aged are those who, before all things, desire not to make a mistake. Logic is the olive branch from the old to the young, the wand which in the hands of youth has the magic property of creating science.

A. N. WHITEHEAD

DR. HALDANE'S SILLIMAN LECTURES

DR. J. S. HALDANE, of the University of Oxford, gives the Silliman lectures at Yale University on October 9, 10, 12 and 13. The general subject of the lectures is: Organization and Environment as illustrated by the Physiology of Breathing. The topics of the separate lectures are:

Lecture I.—The problem presented by the coordinated maintenance of reactions between organism and environment—vitalistic and mechanistic attempts at explanation; The elementary facts relating to breathing; The respiratory center and the blood; Alveolar air and the exact regulation of its CO_2 percentage; Apnea and hyperpnea; Varying frequency of breathing; Physiological effects of varying pressures of gases; Effects of deprivation of CO_2; Effects of air of confined spaces and mines; Effects of compressed air in diving; Influence of the vagus nerves in breathing; Coordination of the responses to central and peripheral nervous stimuli, so that the respiratory apparatus acts as a whole.

Lecture II.—The gases of the blood; Oxyhemoglobin and the conditions of its dissociation; The combinations of CO_2 in the blood and their dissociation; Effects of oxygenation of hemoglobin on the dissociation of CO_2; Exact physiological regulation of the blood-gases; Evidence that CO_2 acts physiologically as an acid; Investigations of

the reaction of blood; Extreme delicacy of the physiological regulation of the blood reaction; Regulation by the lungs, liver and kidneys; Effects of want of oxygen on the breathing; High balloon ascents, CO poisoning, and mountain sickness; Acclimatization to oxygen want:—the Anglo-American expedition to Pikes Peak in 1911; Acclimatization effects of oxygen want on the breathing; Acclimatization effects on the hemoglobin percentage and blood-volume; Acclimatization effects on active secretion inwards of oxygen by the lungs; Factors in acclimatization to want of oxygen.

Lecture III.—Further analysis of oxygen secretion by the lungs; Secretion of oxygen by the swim-bladder; Secretion in other glands; Analogy between secretion and cell-nutrition; The circulatory regulation of carriage of oxygen and CO_2; Regulation by vaso-motor nervous control; Evidence that this control depends upon the metabolism of the tissues; Evidence that the heart's action in pumping blood depends on the same conditions; Part played by contraction of the veins; The blood as a constant internal environment; Regulation of this internal environment by the kidneys; Regulation by other organs; Regulation after bleeding and transfusion; Regulation of the external environment; In reality the constancy of the internal or external environment is a balance between disturbing and restoring influences, each of which persists; The ordinary idea of "function" in an organ is misleading; "Causes" and "stimuli"—physiology as an endless maze of causes.

Lecture IV.—Examination of mechanistic interpretation of regulation of the environment; Difference between an organism and a machine; Life endures actively and develops; In life the whole is in the parts and the past is in the present; Organism, environment and life-history can not be separated; For biology life and not matter is the primary reality; The true aims and methods of biology; Biology an exact experimental science; Relation of physiological to physical and chemical investigation of organisms; The limitations of existing physical and chemical conceptions; Inadequacy of vitalism; Vitalism the inevitable accompaniment of attempted mechanistic interpretations of life; Individual life as a part of a wider life; The limitations of biological conceptions; Science and religion.

SCIENTIFIC NOTES AND NEWS

Josiah Royce, Alvord professor of the history of philosophy at Harvard University, distinguished for his contributions to philosophy, logic, ethics and psychology, died on September 14, in his sixtieth year.

The British government has appointed two committees to inquire, respectively, into the position of science and modern languages in the system of education of Great Britain. The members of the committee on science are: Sir J. J. Thomson (chairman), the Rt. Hon. F. D. Acland, Professor H. B. Baker, Mr. Graham Balfour, Sir William Beardmore, Bart., Sir G. H. Claughton, Bart., Mr. C. W. Crook, Miss E. R. Gwatkin, Sir Henry Hibbert, M.P., Mr. William Neagle, Mr. F. G. Ogilvie, C.B., Dr. Michael Sadler, C.B., Professor E. H. Starling, Mr. W. W. Vaughan, Mr. F. B. Stead, inspector of schools, secretary. This committee is instructed "to inquire into the position occupied by natural science in the educational system of Great Britain, especially in secondary schools and universities; and to advise what measures are needed to promote its study, regard being had to the requirements of a liberal education, to the advancement of pure science, and to the interests of the trades, industries and professions which particularly depend upon applied sciences."

Sir Charles H. Bedford has been appointed general secretary of the newly constituted Association of British Chemical Manufacturers. The business of the association is for the present being carried on at the offices of the Society of Chemical Industry.

Dr. I. J. Kligler, who has been in immediate charge of the bacterial collection of the department of public health of the American Museum of Natural History, has resigned to accept a position with the Rockefeller Institute. His place will be taken by Thomas G. Hull, Ph.D. (Yale, '16).

The Boston City Council has passed an ordinance that will give the city police court a medical department and psychologic laboratory. All offenders will pass through this department, the verdict of which as to their mental condition will be taken into consideration before sentence is pronounced. Dr. Victor V. Anderson is appointed as head.

PROFESSOR CHARLES SMITH PROSSER, head of the department of geology of the Ohio State University, has died at the age of fifty-six years. His body was found in the Olentangy River, near the university campus, on September 18. Dr. Prosser received his bachelor's, master's and doctor's degree at Cornell University and was instructor in paleontology there. Later he was paleontologist of the U. S. Geological Survey and professor at Washburn and Union Colleges, going to the Ohio State University in 1899. He was the author of important contributions to stratigraphical geology and paleontology.

WILLIAM ESSON, since 1897 Savillian professor of geometry at the University of Oxford, has died at the age of eighty-eight years.

S. B. MACLAREN, professor of mathematics in University College, Reading, died on August 14, as the result of wounds, while serving in the corps of engineers of the British army.

DR. C. C. CLOUGH, of the Scottish Geological Survey, died on August 27, aged sixty-three years.

WE learn from *Nature* that Captain A. R. Brown, formerly science master at Buckhaven High Grade School, and Second Lieutenant H. Watson, mathematical master at Ormskirk Grammar School, have both been killed in action.

DR. A. CHARPENTIER, professor of medical physics at Nancy, has died suddenly in his sixty-fifth year.

DR. WALTER ZURHELLEN, formerly an assistant director of the National Astronomical Observatory at Santiago, Chili, is, according to a wireless dispatch from Berlin, dead as a result of wounds received on the battlefield.

Two offices in the health department of the District of Columbia are created by Congress in the appropriation bill enacted September 1. A chief medical and sanitary inspector is to be appointed, who, under direction of the health officer, is to give his whole time to, and exercise direction and control of, the medical and sanitary conditions of the public schools, at a salary of $2,500 a year. He will assume charge of the thirteen medical inspectors and five graduate nurses now in the service. A chief food inspector, at $1,800 a year, is authorized to have general supervision and control of the food inspection service, comprising seventeen subordinate inspectors.

IN central Alaska south of the Yukon River there is a large area which prior to 1915 was practically unknown. In the summer of 1915 a small United States Geological Survey party in charge of H. M. Eakin made a rapid exploration from Tanana River at Cosna to the headwaters of Nowitna River and thence down the Nowitna to the Yukon. A preliminary statement of the important geologic and topographic observations made on that expedition has recently been published by the United States Geological Survey, Department of the Interior, as part of Bulletin 642, entitled "Exploration in the Cosna-Nowitna Region." Much time has been spent by a few prospectors in a search for placer gold on Nowitna River, but so far as is known the occurrence of commercial placers in that region has not been demonstrated. In much of the region prospecting is beset with considerable difficulty, owing to the great depth and breadth of the alluvial filling in the larger valleys. Although no lodes have yet been discovered the evidence available seems to suggest that the gold in the bedrock was probably introduced as a result of the igneous activities that produced the monzonites and granites, so that gold is most likely to be found near these intrusive masses. The map accompanying this report indicates the distribution of these intrusive rocks as well as of the other geologic formations.

DR. LUCY L. W. WILSON, excavating for the Philadelphia Commercial Museum, has closed her camp at Otowi, New Mexico. In this, her second season, she has (*a*) excavated 165 rooms and a kiva in the large pueblo; (*b*) located fourteen pueblos (two of them hundred room houses) on low ridges south of the large pueblo; (*c*) excavated fourteen rooms and a kiva in these smaller pueblos; (*d*) excavated and cleaned out the rooms in two three-story cliff dwellings in the mesa north and west of

the large pueblo; (e) explored the cave dwellings in the southern mesa and the caves in the so-called "tent villages." No certain evidence of prehistoric occupation was found in either case, in spite of reports to the contrary. Nine hundred and five artifacts were catalogued: 613 of stone, 159 of pottery, 88 of bone, 25 miscellaneous (fabric, rope, games, pendants, etc.) together with 21 burials and 53 evidences of food. Twenty-seven pieces of pottery were taken out whole, including five *tinajes*. The most important single find was that of an anthropomorphic figure of clay, originally colored red, with turquoise eyes and a turquoise in the chest. The work of excavation will be continued for at least another season.

According to the London correspondent of the *Journal* of the American Medical Association the births registered in England in the fourth quarter of 1915 corresponds to a rate of 19.5 annually per thousand of the population. This rate is 4.6 per thousand below the mean birth rate in the ten preceding fourth quarters and 2.7 below the rate in the corresponding period of 1914; it is the lowest birth rate recorded in any quarter since the establishment of civil registration. The natural increase of population in England and Wales last quarter by excess of births over deaths was 46,368, against 87,995, 89,045 and 77,394 in the fourth quarters of 1912, 1913 and 1914, respectively. The deaths registered in the same quarter correspond to an annual rate of 14.6 per thousand persons living; this rate is 0.3 per thousand above the mean rate in the ten preceding fourth quarters, and 0.7 per thousand above the rate in the fourth quarter of 1914. During the year 1915 there were 814,527 births and 562,326 deaths registered in England and Wales. The natural increase of population, by excess of births over deaths, was, therefore, 252,201, the average annual increase in the preceding five years having been 378,360. The number of persons married during the year was 720,052. The marriage rate was 19.3 persons married per thousand of the population, which is 3.5 per thousand above the rate in 1914 and higher than the rate in any other year on record. One of the phenomena of the present time is the war wedding. The greater part of the young men of the country have joined the army and often marry before leaving for the front. The reason generally appears to be financial. If they join the ranks their wives are entitled to separation allowances, and if they are killed, to pensions. In the better classes, from which the officers usually come, the desire that their fiancées shall succeed to their property is another motive. Compared with the average in the ten years 1905–1914, the marriage rate in 1915 showed an increase of 3.9 per thousand. The birth rate was 21.8 per thousand of the population, which is 1.8 per thousand below the rate in 1914, and lower than the rate in any other year on record. Compared with the average in the ten years 1905–1914, the birth rate in 1915 showed a decrease of 3.6 per thousand. The death rate in 1915 was 15.1 per thousand, which was 1.2 per thousand above the rate in 1914. Compared with the rate in the ten years 1905–1914, the death rate in 1915 showed an increase of 0.7 per thousand.

We learn from *Nature* that at the annual general meeting of the Chemical Society held at Burlington House, Dr. Alexander Scott presided, and a discussion took place with regard to the removal from the list of those honorary and foreign members who are alien enemies, and it was decided to refer the matter to the council for further consideration. It was with great pleasure the president announced that the following donations had been made to the research fund: (a) £1,000 from Dr. G. B. Longstaff, whose father, by his gift of a similar amount, was largely instrumental in founding the research fund forty years ago; (b) £1,000 from Mrs. and Miss Müller, in commemoration of the late Dr. Hugo Müller's long connection with the society; (c) £500 from Dr. Alexander Scott, to mark his appreciation of the valuable work done by the research fund, and in commemoration of the seventy-fifth anniversary of the society. Professor G. G. Henderson and Professor A. Lapworth were elected new vice-presidents, and Mr. A. Chaston Chapman, Mr. C. A. Hill, Dr. R. H. Pick-

ard, and Dr. F. L. Pyman were elected as new ordinary members of council.

THE Chemists' Club of New York announces the establishment of another scholarship fund, the income from which, approximately $400 per year, is to be devoted to assisting financially deserving young men to obtain education in the field of industrial chemistry or chemical engineering. This scholarship has been endowed by Mr. Wm. F. Hoffmann. Its benefits will be open to properly qualified applicants without restriction as to residence, and may be effective at any institution in the United States which may be designated or approved by the Chemists' Club. In accordance with the deed of trust applicants must, as a minimum qualification, have completed a satisfactory high-school training involving substantial work in elementary chemistry, physics and mathematics and present a certificate showing that they have passed the entrance examination requirements of the College Entrance Examination Board or its equivalent. Preference will be given to young men who have supplemented these minimum qualifications with additional academic work, especially in subjects which will form a suitable foundation for the more advanced study of applied chemistry and chemical engineering. All inquiries should be addressed to the Hoffmann Scholarship Committee of the Chemists' Club, 50 East 41st Street, New York City. Applications for the next academic year should be in the hands of the committee on or before June 1, 1917. The scholarship will be awarded and candidates selected and notified on or before July 1.

IN his anniversary address to the Society of Antiquaries, the president, Sir Arthur Evans, made the following observations:

I am well aware that the question of the expulsion, or at least suspension, of German honorary members of this and other learned societies in this country is in the air. There seems, at the same time, to be a general consensus of opinion that if any action in this matter be considered desirable it should be taken in common. To this end your council have empowered me to submit proposals on their behalf. But I will not attempt to conceal from the society my own feelings on this grave matter. . . . The existence among German honorary fellows of savants belonging to that noble class of which the late Dr. Helbig stood forth as a conspicuous example—to whom the brotherhood of science was a bond at least as great as that of nationality and language—should give us pause before we carry out any too sweeping measures. In spite of the "Gospel of Hate," let it be said to their credit, the learned societies and academies of Germany, with inconsiderable exceptions, have refrained from striking their English members from their rolls. In spite of official pressure, the Academy of Berlin has twice refused to take this action. I myself am not ashamed of confessing that I have received, in the period of the war itself, cordial and even unsolicited assistance from a German archeologist, occupying a high official position. . . . In these times of intolerable provocation we, and members of kindred societies, who stand on the neutral ground of science have a high duty to perform. That there should be a serious and prolonged estrangement of the peoples of the British commonwealth from those of the German empire has become inevitable. But this does not affect the immutable condition of all branches of research, which is their essential interdependence. We have not ceased to share a common task with those who to-day are our enemies. We can not shirk the fact that to-morrow we shall be once more laborers together in the same historic field. It is incumbent on us to do nothing which should shut the door to mutual intercourse in subjects like our own, which lie apart from the domain of human passions, in the silent avenues of the past.

WE learn from the *British Medical Journal* that the museum of the French army medical service installed at the Val-de-Grâce military hospital under the direction of Professor Jacob, was recently formally opened by M. Justin Godard, under secretary of state of the sanitary service. On the ground floor are a library, an archives room, and others for specimens, mouldings and apparatus. The first floor is given up to a collection of the instruments of destruction—bullets, shells (incendiary, shrapnel, asphyxiating and explosive gases), aerial torpedoes, Zeppelin and aeroplane bombs—used by the Germans; alongside these are specimens of protective apparatus (helmets and masks). Then comes a miniature exposition of sanitary cantonments, special

beds, and other hygienic inventions for use at the front. A laboratory of antityphoid vaccination displays the apparatus, the preparations used, and the graphic records. Painted sculptures by M. Jean Larrivé illustrate the working of the sanitary service. A series of reliefs shows first aid in the trenches, the transport of a badly wounded man, the arrival at the first line dressing station, and the interior of the station. A room is set apart for surgical instruments and sterilizing apparatus, with models showing the disinfection of wounds by the Dakin method.

A valuable collection of foreign and domestic woods in panel form is being installed on the second and third floors of the rotunda in the new $250,000 Forestry Building of the State College of Forestry at Syracuse. For the past two years search has been made throughout the country for available commercial varieties of wood native to this country, as well as the important commercial woods from South America, Mexico, the West Indies, Africa and the East Indies. Among the rare foreign woods that will be displayed as panels around the rotunda in the College of Forestry building are African gaboon, East India koa, marblewood, East India rosewood, satinwood, camphor wood, teak, Circassian walnut and eight different kinds of mahogany. Among the western woods of this country displayed are Douglas fir, California redwood, sugar pine, western yellow pine, Sitka spruce, Port Oxford cedar, incense cedar and several varieties of eucalyptus. The southern forests are represented by cypress, southern hard pine, North Carolina pine, red and black gum, cucumber and persimmon. A great variety of native hard and soft woods found in New York are the nucleus around which these rarer woods are gathered. The collection of panels of native and foreign woods built into the rotunda of the College of Forestry building at Syracuse are being finished carefully to bring out the natural grain to best effect and at the same time to detract as little as possible from the native color and natural wood fibers. Each panel is to be labeled with the common and scientific name so that both the student body of the college and the many visitors who come to the building may study a permanent exhibit of unusual interest and value. Lumber manufacturers' associations and lumbermen throughout the country have been cooperating very cordially with the New York State College of Forestry in supplying these panels.

A machine for testing the strength of boxes has been devised by engineers of the Forest Service and is in use at the Forest Products Laboratory at Madison, Wisconsin. The machine is the result of experiments made to determine a fair test for all types of boxes. A series of tests in cooperation with the American Society for Testing Materials and the National Association of Box Manufacturers has been carried on during the past year to determine the strength of boxes of various woods and of different construction. Over four and a half billion feet of lumber is used for box making every year, and on this account the tests are considered important. Moreover, big losses are caused by the breakage of boxes in transit, and all parties concerned are said to be anxious to determine the best kind of box. The machine consists of a hexagonal drum with 3½-foot sides, which is lined with thin steel sheets. Pieces of scantling bolted to the bottom form what are known as "hazards." In making the tests boxes filled with cans containing water are placed in the drum, which is then rotated. For convenience in observing the results of the tests, the sides and ends of the box are numbered with large figures, and in addition other numbers are placed at specified points on each side. The "hazards" cause the boxes to be carried part way round and then dropped back to the lower level of the drum. Each fall of this sort is a pretty fair imitation of the probable treatment it would receive in shipment. The boxes are watched carefully, and notes are taken on the manner in which they give way and the number of falls required to break them in pieces. In this way it is possible to determine what kinds of woods are best suited for boxes. The tests showed a decided need for a standard classification of box woods, and three

groups have been made, based on the data that were obtained.

LEADING metal-producing companies from all sections of the country will be represented by members of their staff at the meeting of the American Institute of Mining Engineers, which convenes in Arizona on September 18. The country's record production of metal during the past year has greatly stimulated the interest in those general mining topics which will be discussed at the institute's sessions. More than twenty corporations have already expressed a desire to be represented by institute members who may participate in the technical gathering. Some of these are Anaconda Copper Mining Co., the largest copper producing company in the country; American Smelting and Refining Co., the largest lead-producing company; Ray Consolidated Copper Co., Treadwell and Alaska Juneau mines, Miami Copper Co., and the New Jersey Zinc Co. Among the engineers who will be present are L. D. Ricketts, Benjamin B. Thayer, William L. Saunders, Sidney J. Jennings, George D. Barron and Philip N. Moore. A special train from New York will be the traveling headquarters, the train moving from point to point in Arizona each day during the week of the convention. Some seventy papers have been prepared for discussion at the meeting. These papers bear largely upon new methods of production and the mining outlook in various parts of the world.

UNIVERSITY AND EDUCATIONAL NEWS

UNDER the will of William Watson Lawrence, of Pittsburgh, Princeton University will ultimately receive the residue of his estate, estimated at more than $750,000.

PROFESSOR CARL T. DOWELL, instructor of chemistry at the University of Texas, Austin, has been elected associate professor of chemistry at Tulane University.

THE following appointments and changes are announced from the University of Illinois: Professor Richard C. Tolman, recently at the University of California, has been appointed professor of physical chemistry to succeed Professor E. W. Washburn, who has been appointed head of the department of ceramics. Dr. Roger C. Adams has been appointed assistant professor of organic chemistry to succeed Dr. C. G. Derick, who is organizing a research laboratory for the Schoellkopf Aniline and Chemical Works in Buffalo. Dr. Horace G. Deming, recently returned from the Philippines, has been appointed associate in chemistry to assist in the instruction in general chemistry and qualitative analysis. Professor C. W. Balke, formerly at the head of the division of general chemistry and qualitative analysis is organizing a research laboratory for the Pfanstiehl Company in North Chicago which is engaged in the application of rare metals to industrial uses.

DISCUSSION AND CORRESPONDENCE

VITALISM

I HAVE read with much interest the addresses that have appeared in SCIENCE, forming part of a symposium on "The Basis of Individuality in Organisms." But I have not noted that two well-known facts, that seem to me of major importance to the discussion, have been jointly focused on the problem. May I mention them, and briefly suggest their bearing?

1. I assume all would agree that non-perceptual realities—Spencer's Unknowable, Kant's Ding-an-sich, Locke's Something, I know not what, that supports sensations—exist, and are the kernel of *all* matter, dead and living. These realities—whose natures remain so dim to our inquiries—it is that *behave* in the ways laboriously and skilfully discovered, described and formulated by natural science. Their existence and basal activity might, further, be thought to validate vitalism. For the active beings (*i. e.*, themselves) of which conscious organisms are aware are the very realities that behave after the conscious fashion, and their natures might reasonably be thought to throw light on their behavior, as has, in fact, been

the case. But such an inference goes too fast.

2. The behavior of certain groups, even when viewed phenomenally, in abstraction from their realities, as natural science views them, is different from the behavior of the aggregate of their components ungrouped; and the behavior of the components grouped is different from their behavior ungrouped; different as regards the scientific laws they observe. The proper number of electrons act differently, individually and collectively, before and after being grouped into an atom of helium. And so with the atoms that form molecules; the molecules that form cells; the cells that form organisms; the organisms that form crowds or societies.

Here, as I see it, emerges the question of the acceptance or rejection of vitalism, *as a factor in natural scientific explanation*—1, above, shows we must accept it as a fact. If it can be successfully maintained that a *full* knowledge of the *perceptual behavior* of electrons, atoms and molecules, before they are grouped and regrouped into cells and organisms, will enable us to predict their behavior, and the behavior of the cells and organisms they form, after the grouping and regrouping, then vitalism is not needed for natural scientific explanation. If not, non-perceptual realities being existent, potent and observable, in the case of conscious beings, they, and therefore vitalism, must be availed of to eke out our otherwise incomplete explanations. Of course, our present knowledge does not permit such predictions, and therefore ordinary intercourse, the social sciences, and psychology, are *per force* vitalistic in explanation, for the present at least. But the antivitalists maintain that full prediction will come some day, and that meantime we should not be scientifically—I should say natural scientifically; psychology at least is a science—satisfied till it does; while the vitalists believe our knowledge of outer perceptual happenings never will permit full prediction, though it probably will approximate more and more closely to doing so.

Whichever side is right, two facts should not be forgotten. (1) Though living cells and organisms act according to the chemical and physical laws observed by electrons, atoms and molecules in their simpler groupings, they also, *and in addition,* behave after the higher vital fashion; *i. e.,* intelligently and any explanation offered by natural science that pretends to explain intelligence *away* is incorrect or incomplete, because false to the facts it is bound to respect. (2) The *real agents,* whose activities the sciences of nature, among others, are called upon to describe and explain, are, in the case of us men, the Egos of which we are severally confusedly conscious.

In sum, then, natural scientists, as such, must deny vitalism, in order to achieve the maximum of explanation in quantitative and phenomenalistic terms; but practical and philosophic men, viewing their problem entire, and engaged in the larger game of living, must recognize and reckon with the effective reality of the human (and animal) Ego.

I ask indulgence for the dogmatic tone, assumed in the interest of terseness; it conceals not a few modesties.

S. E. Mezes
The College of the City of New York

THE ANIMAL DIET OF EARLY MAN

It may be the merest speculation to say what early man did or did not eat, but, there appears to be rather strong zoological evidence that man and his ancestors have long indulged in three forms of animal food which to-day are commonly found in markets. The perfect adaptation to their definitive and intermediate hosts and the rather high degree of differentiation of the three large tapeworm parasites of man must impress itself upon every one who gives the matter consideration and yet it is a point which I have not seen mentioned in the books on animal parasites with which I am familiar.

The tapeworms referred to are the beef tapeworm, *Tænia saginata;* the pork tapeworm, *Tænia solium,* and the fish tapeworm, *Dibothriocephalus latus.* The definitive host of the two tænias is man, and I believe man alone. The intermediate host of *Tænia saginata* is *Bos taurus.* The common intermediate host of *Tænia solium* is the pig, *Sus scrofa,* less

commonly man himself, very rarely other animals. Both these tapeworms are rather highly specialized and do not appear to be readily adaptable to other hosts. The conclusion seems clear that man has been eating cattle and pigs or their immediate ancestors, and perhaps himself, for as many ages as needed for these tapeworms to attain their present degree of differentiation. We have no evidence that species of any kind are rapidly produced, and the parasites have probably had as slow an evolution as man himself. The fish tapeworm has other definitive hosts than man, notably the dog and the evidence is not conclusive that early man was piscivorous. The ease, however, with which man becomes infested with this parasite might indicate that he had eaten uncooked fish for a long period.

The adaptability of trichina, *Trichinella spiralis,* for man and pigs is rather significant in this connection, but trichina seems to thrive so easily in almost any mammalian host that not much weight can be attached to that parasite as indicating a pork diet for early man.

The idea of the concomitant evolution of these human parasites, of man, and of the animals serving as food for him and intermediate hosts for the parasites has interested me for some time. It has recently been brought to the foreground by Gregory's "Studies on the Evolution of the Primates"[1] in which he so graphically describes (pp. 342–344) the evolution of human food habits. On different grounds from parasitology Gregory concludes that the wild boar was "one of the first medium-sized animals that the nascent Hominidæ would be successful in killing." The only other animal mentioned by him as probable food of early man is the horse. Our knowledge of the beef tapeworm seems to indicate that *Bos taurus* or its progenitors were eaten as well as early horses. There is nothing to show that horses were not eaten, unless the rather widespread abhorence of eating horseflesh at the present time can be construed that man never adapted himself to that diet as he did to beef.

[1] *Bull. Amer. Mus. Nat. Hist.*, Vol. 35, pp. 239–355, June 16, 1916.

It is not beyond possibility that the acquirement of a meat diet by the vegetarian pre-men may by improvement of nutrition, by shortening of digestive processes, and by stimulating properties of proteins and their split-products have played an important part in man's evolution over his vegetarian competitors.

M. W. LYON, JR.
GEORGE WASHINGTON UNIVERSITY

SCIENTIFIC BOOKS

Napier Tercentenary Memorial Volume. Edited by CARGILL GILSTON KNOTT. Published for the Royal Society of Edinburgh by Longmans, Green and Company. London, 1915. Pp. xii + 422. Price, $7.00.

The International Congress which met at Edinburgh from Friday, July 24, to Monday, July 27, 1914, to commemorate the tercentenary of the publication of John Napier's "Mirifici Logarithmorum Canonis Descriptio" was the last great international assembly of scientists before the Great War. Appreciations of English scientists and congratulatory addresses by German scientists and German universities, in honor of an Englishman, will probably not soon be seen again.

The variety of interests touched by such an invention as logarithms, in its developments, is so well illustrated by the papers of this memorial volume that it seems desirable to present the list.

"The Invention of Logarithms," by Lord Moulton, president of the congress.

"John Napier of Merchiston," by Professor P. Hume Brown, University of Edinburgh.

"Merchiston Castle," by George Smith, master of Dulwich College, formerly headmaster of Merchiston Castle School.

"Logarithms and Computation," by J. W. L. Glaisher, Trinity College, Cambridge.

"The Law of Exponents in the Works of the Sixteenth Century," by Professor David Eugene Smith, Columbia University.

"Algebra in Napier's Day and Alleged Prior Inventions of Logarithms," by Professor Florian Cajori, Colorado College.

"Napier's Logarithms and the Change to Brigg's Logarithms," by Professor George A. Gibson, University of Glasgow.

"Introduction of Logarithms into Turkey," by Lieutenant Salih Mourad, of the Turkish navy.

"A Short Account of the Treatise, 'De Arte Logistica,'" by Professor J. E. A. Steggall, University of St. Andrews, Dundee.

"The First Naperian Logarithm Calculated before Napier," by Professor Giovanni Vacca, University of Rome.

"The Theory of Naperian Logarithms Explained by Pietro Mengoli (1659)," by Professor Vacca.

"Napier's Rules and Trigonometrically Equivalent Polygons," by Professor D. M. Y. Somerville, Wellington University, New Zealand.

"Bibliography of Books Exhibited at the Napier Tercentenary Celebration, July, 1914," by Professor R. A. Sampson, University of Edinburgh.

"Fundamental Trigonometrical and Logarithmic Tables," by Professor H. Andoyer, University of Paris.

"Edward Sang and his Logarithmic Calculations," by Professor C. G. Knott, University of Edinburgh.

"Formulæ and Scheme of Calculation for the Development of a Function of two Variables in Spherical Harmonics," by Professor J. Bauschinger, University of Strassburg.

"Numerical Tables and Nomograms," by Professor M. d'Ocagne, l'Ecole Polytechnique, Paris.

"On the Origin of Machines of Direct Multiplication," by Professor d'Ocagne.

"New Table of Natural Sines," by Mrs. E. Gifford.

"The Arrangement of Mathematical Tables," by Dr. J. R. Milne, University of Edinburgh.

"Note on Critical Tables," by Mr. T. C. Hudson, of the Nautical Almanac staff.

"On a Possible Economy of Entries in Tables of Logarithmic and Other Functions," by Professor Steggall.

"The Graphical Treatment of some Crystallographic Problems," by Dr. A. Hutchinson, Pembroke College, Cambridge.

"A Method of Computing Logarithms by Simple Addition," by William Schooling.

"How to Reduce to a Minimum the Mean Error of Tables," by A. K. Erlang, Copenhagen University.

"Extension of Accuracy of Mathematical Tables by Improvement of Differences," by Dr. W. F. Sheppard.

"Unpublished Tables Relating to the Probability-Integral," by Dr. Sheppard.

"A Method of Finding Without the Use of Tables the Number Corresponding to a given Natural Logarithm," by Dr. Artemas Martin, of the U. S. Coast and Geodetic Survey.

"Approximate Determinations of the Functions of an Angle, and the Converse," by Mr. H. S. Gay, of Shamokin, Pa.

"Life Probabilities; on a Logarithmic Criterion of Dr. Goldziher and on its Extension," by M. Albert Quiquet, general secretary of the Institute of French Actuaries.

In addition to the above scientific papers the volume includes a record of the proceedings of the congress, with a list of the members, and subject and name indices.

Of particular interest is the announcement of new tables, prepared or under preparation, made at this congress. Mrs. Gifford has constructed and published a table to every second of arc of natural sines to eight places of decimals. Such tables will be increasingly in demand since the larger calculating machines are supplanting in many instances logarithms. No little surprise is occasioned by the fact that a mathematician and astronomer of the ability of Professor Andoyer should have devoted several years to the laborious task of computation of tables. The partial fruit of this effort is the publication of the logarithms of the trigonometrical function for every ten seconds of arc to fourteen places of decimals; a large quarto volume of 600 pages, appearing at Paris in 1911. Following this there is in course of publication, evidently delayed by the war, a similar table of the natural functions, to form a quarto volume of about 1,000 pages. Professor Andoyer contemplates further a 14-place table of logarithms of numbers between 100,000 and 200,000. Another set of tables which may be published, and which would render unnecessary the last work mentioned, is the tables of logarithms to fifteen places of the natural numbers from 100,000 to 370,000 by Dr. Edward Sang. The computer resided in Edinburgh where he died in 1890. His tables are accurate to fourteen places, and the manuscript was prepared with such care that it would lend itself admirably to reproduction by photographic processes; to include his tables

of logarithms to 28 figures of the numbers from 1 to 10,000 and to 15 figures of the numbers from 100,000 to 200,000 will require a volume of 1,100 pages.

In the paper by Mr. H. S. Gay the final formulæ are unfortunately incorrectly printed (p. 367). Corrected these should read, as follows:

$$\alpha = \frac{\sin \alpha}{.01147 + .006 \cos \alpha}, \quad \alpha \text{ less than } 45°.$$

$$90 - \alpha = \frac{\cos \alpha}{.01147 + .006 \sin \alpha}, \quad \alpha \text{ greater than } 45°.$$

It is interesting to note that the author, a practising engineer, arrived at his approximate determinations of the sine and cosine by a consideration of first and second differences; similar considerations appear in the earliest tables of sines, in the Hindu Surya Siddhanta and in the work of Aryabhatta, a Hindu astronomer of the sixth century A.D.

The historical notes in connection with the conception and development of logarithms are of real interest. Professor David Eugene Smith discusses admirably the treatment in early works on algebra and arithmetic of the law of exponents. Any careful study of the evidence presented by Dr. Smith will show that the way was being well prepared for the invention of logarithms, so that no surprise need be occasioned by the fact that other claimants to the honor of the discovery have their *patriotic* supporters. Professor Florian Cajori meets in a definite and decisive manner the arguments which have been advanced in favor of the priority in the field of the Swiss writer, Joost Bürgi, sometimes claimed as a German. Cajori says:

> They compare Bürgi's supposed date of invention with Napier's date of publication, and therefrom do not conclude, as they legitimately could, that Bürgi was an independent inventor, but they conclude, as they can not legitimately do, that Bürgi's invention was prior to Napier's, or that Bürgi very probably lost priority simply because of failure to publish his logarithms as soon as invented by him.

This memorial volume is marred by the mistaken efforts to ascribe to Napier the discovery of imaginaries, and the introduction of the decimal point. Numerous writers, notably Cardan and Bombelli, had a much more profound grasp of imaginaries than is anywhere exhibited by Napier. So far as the decimal point is concerned Pitiscus in his "Trigonometry" of 1612 preceded by four years Wright, or Napier, in the use of the comma which appears in Wright's 1616 translation of the "Descriptio" and in Napier's "Rabdologiæ" of 1617; that Napier was familiar with the work of Pitiscus is proved by the fact that in both the "Descriptio" and the "Rabdologiæ" Pitiscus is cited. The spread of the decimal system was greatly facilitated by Napier's adoption, but it is not warranted to ascribe to him any "share in the improvement of decimal arithmetic."

The historical notes (pp. 159–161) to the article on the "De Arte Logistica" are replete with errors. In the dates on the progress of arithmetical and algebraical printing Lucas de Burgo comes first, followed by Cardan with "the next known book." Arithmetics printed before Cadan's work of 1539 occupy 192 pages of Smith's "Rara Arithmetica" while in algebra the well-known works of Grammateus and Ghaligai precede Cardan. Stifel or Stifelius (not Stifellius) did not introduce the $+$, $-$ and $\sqrt{}$ signs. Even the English algebra by Robert Recorde is cited as of date 1552, instead of 1557. The concluding remarks to the effect that in Napier's day and for some time afterwards arithmetic and algebra were no part of the mathematical curriculum is absurd. The solution of the cubic and the biquadratic was effected nearly one hundred years before the time of Napier's great publication; Vieta's introduction of literal coefficients preceded by more than twenty years; the serious study of algebra and arithmetic made in the time of Napier prepared the way for the invention of the analytic geometry and the calculus, introducing the era of modern mathematics.

To his contemporaries Napier's most celebrated work was "A Plaine Discovery of the whole Revelation of St. John," published in

1593 and followed by three Dutch editions between 1600 and 1607, by nine French editions between 1602 and 1607, by four German before 1627, and by several other English editions. In this, following the conclusion that the Pope is Antichrist, the end of the world is set to fall between 1688 and 1700. This type of arithmetical mysticism in the study of "Revelations" appealed to many other mathematicians of the sixteenth and seventeenth centuries, some of whom were not so wise as to set the end of the world sufficiently distant to be safe.

From the time of the earliest known trigonometrical tables of Hipparchus and Ptolemy, probably based upon Babylonian documents, down through the ages there has been a continued interest in such mathematical tables. The Babylonians, the Greeks, the Hindus, the Arabs, the Europeans of the Middle Ages, and many of the nations of the present day have contributed energetic workers to this field. No one can deny to Napier the just claim to having made the greatest contribution for the final construction of tables sufficient for computation purposes of the most diverse types.

Louis C. Karpinski
University of Michigan

A NEW TRIANGULATION SIGNAL LAMP

State, county and city surveyors must look to the national government for the exact geographical positions upon which to base their respective surveys. The duty to establish and furnish these positions devolves upon the United States Coast and Geodetic Survey.

The geodesist determines astronomically with the greatest possible exactness the longitude and latitude of selected principal points, suitably distributed over the whole country. The geographical positions of the many places between these principal points required are ascertained most accurately and economically by means of what is called triangulation. A rough, preliminary or reconnaisance survey reveals those points which are intervisable and most desirable as to distance and other characteristics, to form the corners of connected triangles. From the measured length of one side of a suitably selected one of these triangles and the angles of all the interconnected ones, the exact latitude and longitude of each point is computed.

Though the general principle employed in the measurement of these angles is the same as that applied in the survey of a railroad, a farm, etc., the great distance between the points, varying between ten and a hundred miles or over, requires not only the use of specially large and refined instruments, but also a special means of making the point visible to the observer. This latter is now done, in day time, by reflecting sunlight to the observer from a mirror placed accurately over the point, and at night by means of a specially constructed acetylene lamp.

It is apparent that distances of the magnitude mentioned can be penetrated by either means only under favorable weather conditions, and that many days during a season are lost even when the atmosphere is only slightly clouded by smoke, fog, etc. As the expense to maintain the party, which amounts to from \$50 to \$60 per day, goes on whether observations are made or not, it was thought that advances in illuminating devices made since the lamp now used was adopted might be utilized to increase considerably the intensity of the light directed to the observer, and thereby increase the number of observing nights.

Experiments made with calcium light produced by the oxy-acetylene flame showed this form of illumination to be impracticable by reason of cost and bulkiness of the apparatus necessary.

The storage cell was studied with the view of using electricity as a source of light. Its cost and weight and the difficulties connected with its maintenance were found to be too great. The electric generators with the necessary prime motor were carefully studied, tried experimentally and found to be too heavy for transporting to difficult stations, and doubtful as to continued and unfailing service.

The result of a series of tests of dry cells, which are readily divisible into loads suitable for climbing difficult ascents, however, warranted the design and construction of a new

type of lamp, the use of which, undoubtedly, will increase the present number of observing nights per month by at least twenty-five per cent.

The main part, an ordinary automobile head light, is suitably mounted for directing in the horizontal and vertical; the lamp is provided with an ammeter, a small rheostat and a switch. The whole, packed in a strong case, weighs twenty-three and one half pounds.

In order to obtain most nearly the maximum intensity of the light, it was necessary that the lamp bulb be provided with a filament concentrated to a degree not found in those on the market. One of the lamp manufacturers was induced to make the necessary designs and experimental tests, and submitted a number for trial.

At the present time all the lights of the stations surrounding the observer's station are kept burning continuously from sunset to the closing of the observations for the night. The use of the dry cell was found practicable and not too costly on the assumption that the proposed lamp was to be kept burning throughout the night. The trial of the newly designed lamp by comparison with the present acetylene lamp, however, proved the former so much superior, that it was decided to have the lights shown only on signal, flashed with one of the new lamps by the observer, for the few minutes each time it is observed upon. This reduces very materially the consumption of current and battery cost.

The lamp, after being provided with two additional bulbs, one for medium and one for short distances, was tested by the Bureau of Standards, with the following results:

Apparent candle power, at a distance of 100 ft. Lamp with specially concentrated filament, gas filled, 6 volts, 2.5 amp.	250,000
Automobile lamp, 6 volts, 1.8 amp.	50,000
Flash light lamp, 2.7 volts, .34 amp.	6,000

The candle power of the acetylene lamp now used in the triangulation carried on by the survey, measured under the same conditions, is 1,500.

E. G. FISCHER

U. S. COAST AND GEODETIC SURVEY

SPECIAL ARTICLES

LINKED MENDELIAN CHARACTERS IN A NEW SPECIES OF DROSOPHILA

IN my cultures of a new species of *Drosophila*, tentatively called "species *B*,"[1] several mutants have recently appeared. They have not all been tested fully with respect to their linkage relations, but enough has been learned to suggest some interesting possibilities when considered in connection with the results of Morgan and others on *Drosophila ampelophila*. Three linkage groups have already been obtained in my material, and five characters remain to be studied. Of the linkage groups one is sex-linked and contains four characters, the others are non-sex-linked and are composed, respectively, of one and two characters.

So far as the evidence goes, it indicates a mode of inheritance in this fly entirely comparable with that in *D. ampelophila*, although I have as yet been unable to determine whether or not there is "crossing over" in the male, because the only linked factors thoroughly studied (aside from the sex-linked group) are completely linked and give no crossing over in either sex.

The most interesting feature of the results, as they stand at present, is the apparent correspondence between certain mutant characters in this species and in *D. ampelophila*. Four of the characters I have obtained show this correspondence. One of them ("confluent") has already been recorded.[1] It is a dominant, non-sex-linked character, and has a lethal effect when flies are homozygous for it. Its counterpart in *ampelophila* is an almost exact duplicate in appearance, and apparently has the same peculiarities in genetic behavior. There seems to be little doubt that these characters are actually alike in the two species. The other three are "black," "yellow" and "forked." Black has only been studied enough to tell that it is not sex-linked; and since there are two or three factors in *ampelophila* that give a melanistic effect, there is some doubt as to which, if any, is really comparable to the one I have found. But with respect to yellow and forked the case is different, for they not only correspond exactly in appearance, but

[1] Metz and Metz, "Mutations in Two Species of *Drosophila*," *Amer. Nat.*, 1915.

they belong to the same linkage group, in both species. Since this happens to be the sex-linked group it means in reality that three corresponding factors—the sex factor, the yellow factor and the forked factor—are linked in both species. Whether the same degree of linkage obtains in each has not been determined.

It is, of course, too early to generalize from this one case, but certainly the evidence strongly suggests that there is a genetic continuity of factorial associations in these flies. And if the factors are located in the chromosomes it is equally suggestive of a genetic continuity of the chromosomes.

So far as I know this is the first clear case of the kind on record, and since the work promises further evidence on the same point a word may be said regarding the chromosomes of the species concerned. As is well known *Drosophila ampelophila* has four pairs of chromosomes—two of large euchromosomes, one of shorter sex-chromosomes and one of very small "*m*-chromosomes." In contrast to this the species I am breeding has six chromosome pairs, of which only two resemble those in *ampelophila*. The latter are the sex-chromosomes and the "*m*-chromosomes." The other four pairs replace the two euchromosome pairs of *ampelophila* and are individually about half their size.[2]

Upon the chromosome hypothesis characters in this new species should fall into six linkage groups instead of four. And what is of much greater interest, if present indications are reliable, it may eventually be possible to compare these groups (and hence the chromosomes?) individually with those in *ampelophila* by means of corresponding characters. The first step in this comparison may be represented by the sex-linked characters yellow and forked mentioned above.

A more detailed report of these results will be presented as soon as certain experiments now under way are completed.

CHAS. W. METZ

STATION FOR EXPERIMENTAL EVOLUTION,
COLD SPRING HARBOR, N. Y.

[2] See Metz, C. W., "Chromosome Studies in the Diptera," I., *Jour. Exp. Zool.*, 1914, p. 50.

BACTERIAL BLIGHTS OF BARLEY AND CERTAIN OTHER CEREALS

AT the Columbus meeting of the American Phytopathological Society the writers reported on a bacterial disease of barley. This was described as a widely occurring disease attacking leaves, leaf sheaths and glumes, early characterized by water-soaked lesions with bacterial exudate, and later by the persistent transparency following the death of the parts invaded. The abstract of this paper appeared in *Phytopathology* (Vol. 6, p. 98). Laboratory and field studies have now been completed which confirm all of the preliminary statements and furnish the data for the publication of the causal organism as a new species. It is a monotrichous rod with a single polar flagellum, hence referable to Migula's genus *Pseudomonas*. Field and laboratory studies have combined to show that it is seed borne, and that in this way it is readily disseminated. This fact accounts for its very general distribution, it having already been collected from eight states. Not only has the development of the disease been traced in the field where infected seed was used, but, in addition, the organism has been secured in pure culture from seed collected two years previously, and successful inoculations with this have proved its continued virulence.

Diseases very similar to the one on barley have been found and studied on wheat, spelt and rye. These have all been proved to be of bacterial origin. From each of these hosts the causal organism has been isolated, and its pathogenicity fully determined. The organisms from these three sources are apparently all one species and they are very similar to the barley blight organism.

This similarity holds for the appearance and development of the disease lesions, and for the morphological and cultural characters of the organisms. All like the barley organism are monotrichous and yellow in culture. The chief difference noted is in the behavior in cross inoculations. The barley blight organism when inoculated on wheat, rye, spelt, oats and barley, infects barley only. The wheat,

rye and spelt organisms all behave alike as to pathogenicity when inoculated on wheat, rye, spelt, barley and oats in that they each infect all these grains except oats. A blade blight of oats quite different in type from the blights of the other grains noted above has also been found in Wisconsin and its bacterial cause determined. This disease apparently corresponds in appearance with the bacterial blade blight of oats described by Manns.[1] From it a monotrichous white organism has been isolated which in pure culture infects oats readily but apparently is not pathogenic on the other cereals listed above.

The detailed account of the studies upon barley blight together with the technical description of that organism as a new species has already been sent to press. The results of the comparative studies on these other bacterial grain blights will be given in a subsequent publication.

L. R. JONES,
A. G. JOHNSON,
C. S. REDDY
UNIVERSITY OF WISCONSIN

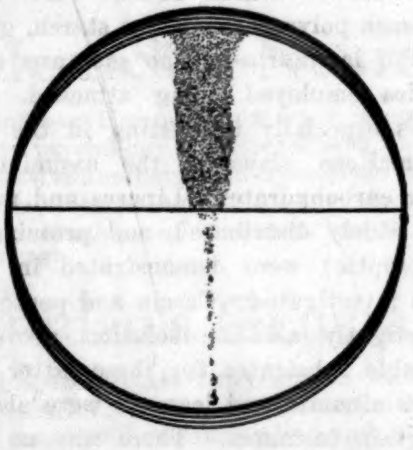

FIG. 1. *Aspergillus* growing on potato agar. The lower half contains oil of nutmeg (1: 200) which inhibits growth of mold.

ANOTHER USE OF THE DOUBLE-PLATE METHOD[1]

IN a study of the antagonism exhibited by certain bacteria for *B. typhosus*, one of us (W. D. F.) used and described a method called by us the "double-plate method."[2] This method enabled us to see and photograph the effect which certain bacteria had in limiting or preventing the growth of *B. typhosus*. The method consisted of dividing a petri dish in halves by means of a small rod or tube and flooding one half of this double-plate with sterile agar and the other with agar containing the antibiont. Over the surfaces of both halves the other antibiont was streaked. The resulting growth of the streaks readily showed the effect of the antagonism.

Some eight years later, Churchman[3] describes an identical procedure for demonstrating the selective action of gentian violet. He makes no mention of our method but substitutes a metal strip for the glass rod and the name "divided plate" for double-plate. He was evidently not aware of our previous description.

Recently we have used this method for deter-

FIG. 2. *Penicillium* on potato agar. Marked inhibition due to eugenol (1: 1,000) in lower half of dish.

[1] Manns, T. F., "The Blade Blight of Oats; a Bacterial Disease," *Ohio Agr. Exp. Sta. Bull.*, 210, pp. 91–167, 1909.

[1] Read at the meeting of the Society of American Bacteriologists, Urbana, Ill., December 28–30, 1915. Publication authorized by the Director of the Wisconsin Experiment Station.

[2] Frost, W. D., "The Antagonism Exhibited by Certain Saprophytic Bacteria Against the *Bacillus typhosus* Gaffky," *Jour. Inf. Dis.*, November 5, 1904, pp. 599–641.

[3] Churchman, "The Selective Bactericidal Action of Gentian Violet," *Jour. Exp. Med.*, Vol. 16, 1912, pp. 221–247.

mining the effect which spices have on micro-organisms. Here the spice or condiment is mixed with the agar and poured on one side of the plate, plain agar on the other and streaks of the organism in use made across both. A modification in the method of preparation has been adopted which obviates the necessity of using rods or metal strips. This consists of cutting semi-discs of muslin (cheesecloth) which are sterilized in the petri dishes. Plain agar is poured over the entire dish and then when the agar is hard the piece of cloth with adherent agar is taken out from each petri dish with sterile forceps and into its place is poured the agar containing the condiment to be tested. The cloth semi-discs are more easily prepared than the rods and the union between the agar in the two halves of the plate is more direct. This, we take it, is an advantage since it readily permits of diffusion. The agar clinging to the cloths need not be wasted but may be saved by throwing the cloths into a funnel and allowing the agar, when liquefied, to drain off into a flask. Instead of plain nutrient agar, potato or wort agar, gelatine or other liquefiable solid media favorable to the growth of organisms to be studied, may be used.

The accompanying figures illustrate the method of use and the character of the results obtained.

W. D. Frost,
Freda M. Bachmann

Department of Bacteriology,
Wisconsin Agricultural Exp. Sta.,
Madison, Wis.

SOCIETIES AND ACADEMIES

ST. LOUIS ACADEMY OF SCIENCE

At a meeting of the St. Louis Academy of Science on March 20, 1916, Dr. A. R. Davis, of the Missouri Botanical Garden, presented a paper on "Enzyme Action in Marine Algæ," of which the following is an abstract:

During the years 1914–15 a general survey was made of the enzymes of certain representative marine algæ. The work was carried on for the most part at the Woods Hole Biological Laboratory since fresh, vigorously growing plants were obtainable in that immediate vicinity. Plants were also collected and carefully dried and with this material the work was further prosecuted at the Missouri Botanical Garden. All investigations where dried tissue was involved, however, were later duplicated with fresh material at Woods Hole. The standard methods of enzyme isolation and determination were employed and where negative results were obtained many modifications of these methods were brought to bear. In summarizing the results obtained, two striking points stand out, *i. e.*, the relative paucity of the number of enzymes demonstrable by standard methods, and the extraordinary slowness with which most of these enzymes act. Especially were both these points true for the "browns." In *Ascophyllum* and *Fucus* of this group catalase was the only enzyme demonstrable, while in *Laminaria* and *Mesoglœa* diastase, lipase, proteinases and catalase were found. Enzyme action was much more easily shown in the "reds" and the "greens" where in addition to the ferments found above, dextrinase, tryptase, ereptase and nuclease could be demonstrated. Oxidase was shown in but two forms, *Agardhiella* and *Ulva*. The rate of action in these two groups was also much faster than it was in the "browns," although here too, such action was slow when compared with that of many of the higher plants.

The carbohydrases found were those acting upon such polysaccharides as starch, glycogen, dextrin and laminarin—in no case any of the disaccharides employed being attacked. This latter fact is especially interesting in the light of the rôle maltose plays in the assimilation of the higher carbohydrates. Lipases and nucleases were quite widely distributed, and proteinases (tryptic and ereptic) were demonstrated in most of the forms investigated. Casein and peptone in neutral and slightly alkaline solution proved the most favorable substrates for these latter enzymes, although albumin and legumin were also hydrolyzed in certain instances. There was no digestion of algal protein, as shown by autolytic experiments, and no splitting of amino acids.

Several factors may enter in to account for the limited number of enzymes formed and the slowness of their action: (1) they may be formed in small amounts in the tissues, or as formed may be inherently slow; (2) inhibiting substances may be liberated upon crushing the cell which may cut down the rate of action or destroy it altogether. Evidence is at hand tending to show that both of these factors may be concerned.

J. M. Greenman,
Corresponding Secretary